ROLE OF TECHNOLOGY TRANSFER IN ABATING CO_2 EMISSIONS

Final Report

1993

Submitted to:

US Agency for International Development

BY
THE TATA ENERGY RESEARCH INSTITUTE

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The project team would like to acknowledge the guidance and support provided by the following, in the preparation of this report.

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Foreword

This study on the role of technology transfer in abating CO_2 emissions is an integral phase of a larger project on estimation of GHG emissions from Asia and Brazil and policy responses for their minimization undertaken by the members of the Asian Energy Institute along with a group of researchers from Brazil. In the earlier phases of this project the focus was on estimation of emissions and identification of strategies/technologies to abate CO_2 emissions. Computation of likely reduction in CO_2 emissions and the specific costs for each technology was also undertaken.

In this report, as mentioned earlier, the focus is on the issue of technology transfer and the barriers to effecting such transfers. Each country paper has a brief description of on the general country policy that affect technology transfer such as, investment policy, tax incentives, capital financing and foreign exchange control. This is followed by a specific case study for either cogeneration or lighting technology or both in the country papers. In particular, the barriers and opportunities in each of the phases of technology transfer viz.,technology acquisition, absorption, adaptation and development, are addressed and the necessary policy and regulatory changes are identified.

In addition, a description of various notions of equity is also included.

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In this paper, the authors have addressed the issues related to transferring efficient lighting and cogeneration technologies into Brazil. The case study for lighting systems is presented first.

1. Case study of efficient lighting systems in Brazil

1.1 Introduction

This section is about the transfer and absorption of a set of new technologies for more energy efficient lighting. It is the first of a series of papers to analyze the barriers to the market penetration of groups of energy efficient technologies which are, in principle, cost effective. The rapid diffusion of these technologies is of special interest to developing countries, because with its severe financial and environmental constraints on supplying a growing energy service demand are both relieved. In broader terms, energy efficient technologies and systems can add new degrees of freedom in resolving trade offs between environmental and development imperatives. However, these technologies (and the "software" and "systems" associated with them) are mostly not penetrating their markets rapidly in developing countries, even in situations where they offer very high returns, as is the case with several lighting technologies in Brazil Important barriers exist to the penetration of cost effective new technologies. In order to obtain a comparative international perspective, the Asian Energy Institute is coordinating parallel analyses in [illegible] countries, of which this discussion paper is one case. In each country a discrete set of technologies has been chosen.

"Technology", as understood in this work, includes not only equipment "hardware" but the "software" needed to use it well skills, institutions, information and "culture" This "software" is receiving growing attention among those concerned with the diffusion of energy efficient technologies.

The emphasis here is on technology acquisition and absorption rather than on development or even adaptation. This is partly a consequence of the characteristics of market for supplying lighting equipment, which is dominated by a small number of multinationals (see below). But it also reflects a wider belief that most technologies of interest already exist and are proven The main problem is their introduction and penetration in the markets of Brazil and other developing countries.

This paper is restricted to electric lighting technology. As in many developing countries, kerosene is widely used for lighting in rural areas due to the lack of access to electricity. However, the authors have no experience with non-electric artificial lighting sources. It is to be hoped that these lighting sources will be treated in the parallel papers from countries where residential kerosene consumption is relatively more significant than in Brazil. Here it accounts for only 0.2% of oil consumption, and consumption has fallen almost sixty percent since 1980.

1.2 Context for lighting technology transfer and absorption in Brazil

The future evolution of lighting technology and its application is a question of strategic importance for policy towards power sector expansion. As end-use, lighting accounts for about 15% of electricity consumption, but its importance for near-term policy on technology transfer and energy efficiency improvement is greater than this number suggests. First the technical potential for efficiency improvement in basic equipment is very large, perhaps the largest of any kind of end-use There are many cases (see below) where the energy consumption of the basic lamp assemblies supplying the same quantity and similar quality of light falls by a half or more. Furthermore, the technology is commercially proven. Second, the design of the use of these lamp assemblies offers large scope for improvement. For example, most architects in Brazil appear to have only a rudimentary understanding of lighting The solutions adopted often involve unnecessarily high maintenance and operating costs and initially impressive rather than functional lighting There is ample scope to address the factors leading to this situation. In this sense, lighting shares with other areas for energy efficiency improvement, the possibility of significant gains from rethinking the basic "process" of producing a product, the product itself, and how to use the product in a context of financial and environmental restrictions

A third point is that much lighting equipment has, on average, a useful life which is relatively short compared to most investments by consumers which significantly influence energy consumption. Conventional bulbs and lamps last less than one to a very few years While the lighting system is designed to last substantially longer than the lamp, major changes in lamp and other technology combined with new user perceptions of lighting needs and costs can,

in principle, lead relatively quickly to notable changes in the stock of equipment.

These points, plus the sheer visibility of lighting, makes this an interesting area for energy efficiency programs to emphasize in their early phase. A lighting program can show results which increase consumers' awareness of energy efficiency in general. Brazil's early modest efforts at electricity conservation have in fact given considerable emphasis to lighting.

Some individual utilities have had programs of electricity conservation for ten years. A national program, called PROCEL was launched in 1986 to deal comprehensively with barriers to improving energy efficiency (1) Considerable attention was given to defining new technologies of interest, labelling certain appliances, energy audits, and the promotion of more efficient public illumination. Some results were achieved, but the program then suffered cutbacks. In 1990 a special high-level council was created to help orient conservation efforts in general and give them political impetus. This council (GERE-the Executive Group for Energy Rationalization) has achieved some concrete results, especially regarding taxation and import duties (2). The council has recently become less active, but in compensation PROCEL has again become more dynamic.

The supply of lighting equipment and systems is entirely in the private sector At the base of this industry are the manufacturers of lamp. This segment is dominated by a small number of multinationals - Phillips, Silvania, GE and Osram - and is definitely very cartelized within Brazil. The cartel's market is mostly protected against imports, as is the case with most Brazilian industrial cartels This combination of cartelization and protection can create problems for introducing improved technology. For example, PROCEL launched a program to stimulate the installation of more efficient public illumination. This program entailed free marketing for the manufacturers of relevant equipment. It would help them increase volume of sales in the short and medium term, thus reducing unit costs. Unfortunately, the cartel's response was to increase prices, using market power to achieve short-term profit maximization. Another problem, raised in sections 3 & 4 below, is product quality (including lifetime guarantees). Cartelization and protection are widespread in Brazilian industry and appear to act as a factor inhibiting more rapid market penetration of new technology, though it was not possible to

analyze these and other broad economic issues (e.g. inflation) in preparing this paper.

Certainly progress in creating an overall business environment with more competition, less inflation, and reformed regulation will create more auspicious conditions for investment in process productivity and product quality throughout the economy. Yet the existing macro distortions should not paralyse efforts to seek energy efficiency gains (with usually attendant new technology). Indeed the measures described below, ranging from realistic electricity tariffs to norms and information are compatible which broader efforts to reduce distortions.

1.3 Analyses of specific lighting technologies

1.3.1 Efficient first generation incandescent lamps

Multinational companies operating in the country have already manufactured the product and placed it in the market (22W, 36W, 54W and 135W). This was motivated by the government's price control and the attempt of the manufacturers of creating new products whose prices were not controlled. The advertising companies worked hard and there was support from some government institutions The product was removed from the market with the argument that the consumer was becoming confused with the already existing well-known traditional lamps (25, 40, 60, 100W and 150W) and preferred these models. He always thought he was buying a less intensive lamp for a higher or similar price (at the end of the commercialization its price was equalled to that of the conventional lamp), when he chose the efficient lamp

Various conversations between PROCEL/GERE and manufacturers (ABILUX) show that they are not interested in only producing the efficient lamps because

a) it would demand investment of US$ 70 million in order to serve the whole market,

b) it would represent a potential risk of a market invasion of imported conventional incandescent lamps, since consumer is used to the traditional lamp.

c) it would demand a great advertising effort in order to educate the consumer This effort could be co-financed by the government itself.

d) there is some expectation that the incandescent lamp will eventually disappear from the market, surpassed by the technology of the simple fluorescent lamp, known in the market as the compact fluorescent lamp.

The surcharge which has to be included in efficient lamp, due to the additional investment of US$ 70 million is perfectly acceptable considering the benefit offered to the consumer. The Brazilian production surpasses 300 million units/year, which means that an increase of US$ 0.1/unity provides a payback time of a little over 2 years. For an average price of a conventional incandescent lamp of US$ 0.6 and electricity of US$ 0.08/kWh (consumption over 200kWh/month), we see that the saving of 1 3kWh compensates the price increase for the consumer. For a 60W lamp, this represents nearly 200h of consumption (or let us say 400h, supposing that the retail price is US$ 0 2/unity, consequence of US$ 0.1 of the retail margin).

The non-existence of such products in Brazil at present can be easily diagnosed as resulting from poor information and poor popular education as for as market demand is concerned since most of the population is unable to understand the technical and economical advantages associated with the first generation of incandescent light bulbs.

Shortage of capital also create a barrier The investments required to convert all the existent incandescent light factories can be recovered in a reasonable time span, as discussed above, but there are other investment opportunities in the country which can provide payback times shorter than two years

1.3.2 Second generation incandescent lamps

The awaited product "lamp in a lamp" is already in the American and European market One can find halogen lamps fitted inside a conventional lamp This product is interesting because the halogen lamp can reach an efficiency of 20 to 22 lumen/W, almost double of the conventional incandescent. Besides this the halogen lamp lasts 2,000h instead of the 1,000h of the conventional one

Another great advantage is that given the small volume of its filament (if compared to that of the conventional lamps) it is possible to construct a good reflection system with reduced dimensions, projecting almost all the light to a determined area In this way, a product which is available in the American market, a "floodlight" lamp, with the reflector system incorporated in the

extreme part of the bulb, is capable of supplying light equivalent to a 150W lamp, with a consumption of only 90W. This product is economically efficient because its consumer price is US$ 4.00 while a conventional floodlight costs US$ 2.50. This difference in cost (US$ 1.50), to save 60W is compensated with 310h of operation (at US$ 0.08/kWh).

This type of "lamp in a lamp" does not exist in the Brazilian market. Halogen lamps are produced in the country so it will not be very difficult to see that the new product in our multinationals operating in Brazil have access to the technology. The problem is essentially related to the product's absorbing capacity in the national market. It is estimated at the present, demand for halogen lamps of general use (including the ones used in the car industry) in the Brazilian market is 1.2 million units/year, 30% of which are imported.

Floodlight lamps are sold in very small quantities in the country. The estimated annual market is of 2.5 million units and its cost is 4 times the cost of the 100W conventional incandescent lamps. Thus it is difficult to motivate the production of "lamps within lamps" in the country while the market does not expand. A natural procedure would be making importation easier and allowing the product to be known among consumers and project engineers. Importation can be made easier through the reduction or even elimination of taxes, which already happens with some fluorescent simple lamps.

1.3.3 Third generation incandescent lamps (or IRF) - the most efficient one

This product is interesting because the halogen lamp, due to a thin layer of material which is deposited in its interior, provides interference for the light and the heat irradiated by the filament, and can reach efficiencies of 28.6 lumen/W (in lamps of 350W) and of 35.6 lumen/W (in lamps of 900W). These numbers are more than 70% higher when compared to the conventional incandescent ones (500W). Besides this, the halogen lamp lasts 2,000h instead of the 1,000h of the conventional lamp.

These products are very new in the market and information about them is totally unavailable. Even at the manufacturers development departments the information is poorly appreciated. A strong change in the managerial attitude of such enterprises must occur. Since they are all multinational what is really necessary is that such companies assume the responsibility to use best technologies in all parts of the world.

1 3.4 Conventional fluorescent lamps

These lamps (15,20,30,40,65 and 110W) are being manufactured in the country for many decades. The average consumer price (US$ 5.36; 3.31; 5.36; 3.31; 10.62; 8.68 respectively) is high if compared to the American market. Total production reaches 30 million units per year.

These lamps, when operated with conventional reactors register a deficiency in relation to the product found in the United States, (40W fluorescent lamps can be acquired in USA retail stores for US$ 1.50). It is difficult to obtain the nominal value of the flux. Fluorescent lamps of 40W with a nominal value of 2,700 lumen, usually supply 2,500 lumen when operated with reference reactors (reactor with strictly defined electrical characteristics) and with nominal current of 430mA. In these conditions, it is generally possible to deliver power of 39W on the lamp's arc, which does not occur when operated with conventional reactors (35W). This problem shows that there is a loss of 10 to 15% of the normal luminous flux, with a reduction of also 10% in the power applied to the lamp Considering that there is a loss of 10 to 15% of the normal luminous flux, with a reduction of also 10% in the power applied to the lamp Considering that there is also spent power in the filaments (=3W) and loss in the reactor, it may be concluded that the loss of up to 15% of the flux occurs with a reduction of the power of 10% or less in the combination lamp and reactor, which means a real loss for the final consumer who is essentially interested in the illumination service at the lowest cost This loss can be even larger if one considers illumination for spaces with areas over $20m^2$ In these spaces, the smallest light flux may require the installation of one or more lamps in the illuminating system This cost of the extra lamp(s) and its installation is a loss for the final consumer

Another problem is the average life of the lamp which is not guaranteed by the manufacturer Data show that fluorescent lamps have an average life of 4,000h, which is low if compared to American literature (8,000h).

These deficiencies are the cause of many discussions; the manufacturers are now questioning the bad quality of various reactors used in the country

The issues detected and discussed above show that a whole new business "culture" must be pursued Such a "culture" should give priority to.

a) quality control

b) preparation and follow-up of production quality norms

c) respect for consumer's rights

This last item is obviously linked with adequate information dissemination and with the cultural level of the population. Requiring efficiency standards equivalent to what is achieved in the developed countries will have the indirect benefit of increasing job opportunities for qualified man-power.

1.3.5 Economical tubular florescent lamps

In this category there are T12 lamps (with a diameter of 38mm) of 37W and T8 lamps (with a diameter of 25mm) of 32W and 16W, with a luminous flux of 2,500, 2,750 and 2,900 lumens for the first (T8) and 1,020, 1,150 and 1,050 lumens for the second respectively This variation is due to the use of deposition technology of conventional phosphorous and phosphorous of three different spectrums (tri-phosphorous) The 32 and 16W lamps show a gain of 20% in the luminous efficiency in relation to the conventional fluorescent lamps of 40 and 20W, when used without white luminaries, and even more than that when used with reflective lamps given their smaller physical dimension, when compared to the conventional fluorescent of nominal power of 40 and 20W respectively.

The lamps with tri-phosphorous, besides presenting a greater initial luminous flux in relation to the conventional phosphorous ones, also have the advantage of showing a lesser decrease of the flux as time goes by This lesser decrease is the important fact for a more efficient project, very often allowing the use of less lamps for the same illumination service, when compared to the conventional phosphorous ones

The main problems requiring improvements are the ones related to the initial flux which almost never reaches the nominal (the same type of problem mentioned in item 3) and the cost problem The 32W lamps with common phosphorous have a price for the consumer which is 20% higher than the 40W lamp, without any justification, except for the novelty of the product The tri-phosphorous lamps have a cost at least 100% higher than conventional phosphorous ones, thus withdrawing a great part of potential consumers This last problem is related only to the possibility of a large scale production since, since in the american market the price differential is only 50%

The small size of the market for such products is a consequence of the shortage of information, the high cost of money and the low technical

qualifications. Due to high cost, manufacturers need to recover the initial investments quickly, thus new products always carry high prices, which limits demand. Small demand on the other hand pushes prices up. Low technical qualifications complicate the development of new products and increase the cost of standard technologies. There are complaints from entrepreneurs not only about such products costs but about other construction costs of industrial buildings and associated infrastructure in Brazil, higher than that would be cost in developed countries.

1.3.6 Mercury lamps for public illumination

These lamps are very common in public illumination in main Brazilian cities The country still uses a reasonable quantity of incandescent lamps (=600.000 units) for this purpose and its most natural substitute is the mercury-vapor lamp. The most used models vary between 125 and 4000W and are preferred for their lower price

Mercury-vapor lamps are sold with the duration expectancy of 12,000 to 15,000h of life, and the available data show a life duration of about 8,000h It is very difficult to determine that the deficiency comes from the lamp because very frequently the discharge current (in the ballast) and control of luminous flux (with the luminary) show a performance in service which is little evaluated and sometimes even does not meet Brazilian Norms

Regarding its luminous flux, the result obtained for the Brazilian product is equal to the lamps produced abroad Unfortunately the local manufacturer does not guarantee the average life of the product, only one of them states the nominal life average obtained in a laboratory in his catalogue.

1.3.7 High pressure sodium-vapor lamps

These lamps (with internal igniter - "startless" lamp) have been used increasingly in public illumination in Brazil. In spite of being more efficient than the mercury one, its market is limited by the production price Part of its components are imported and it is said that implies in an increase in the final cost due to import tariffs. What really happened is that with the liberation of imported goods in the country, these tariffs were reduced and more reductions are expected in 1993 and 1994

Life expectancy is up to 24,000h but the manufacturer does not guarantee this In practice shorter lives have been observed (6 000h) and it has

been blamed on the inappropriate performance of the auxiliary start-up and operating system. In relation to the price, it is also important to verify that for the same amount of luminous flux they cost between 2.5 and 4 times more than the mercury lamps, which is a lot if compared to the price in the United States (where it costs between 2 and 3.5 times mercury lamp).

The performance of mercury and sodium lamps is another evidence of the poor technological level. There is a shortage of qualified people to deal with the problem on the producer and consumer's side Consumer's rights are not respected nor claimed, and this leads to a loss for the whole society.

1.3.8 Simple fluorescent lamps (CFL)

Compact fluorescent lamps have been offered in the Brazilian market for 5 years, with a power of 5, 7, 11 and 13W As all other discharge lamps they need current limitation reactors They are found in the market whether incorporating the reactor or not and they have sockets which are compatible with the conventional incandescent lamps. The units with the incorporated reactor are imported, with no import tax, while the bulbs up to 13W are manufactured in the country by multinationals The market of these products in 1991 was of 0.8 million units of which 63% were produced in the country 33% were assembled in the country with the majority of foreign components and 4% were imported Their retail price is US$ 6 without the reactor, and US$ 11 with the reactor There are also CFL lamps with electronic reactors (introduced this month) in the domestic market, which can also be imported and sold in retail for US$ 15

CFL lamps are manufactured with tri-phosphorous and therefore show good efficiency. In spite of this they do not compete with the efficiency of the conventional fluorescent lamps of 40W because they are designed for small power only

In spite of their high unitary cost, if compared with incandescent lamps, they have advantage of being replaced easily (as happens with incandescent lamps), and of being 4 times more economical and demanding less maintenance due to their average life span of 8,000h Even though this last fact is not guaranteed by the manufacturer, many users are satisfied with the reduction in the cost of replacement

If we consider a power of 12W for the set lamp-reactor (9W) and a period of 8,000 hours (normal life declared for this type of lamp) and if we compared

this system with the traditional incandescent lamp of 60W nominal, we would have a comparison between the respective costs of illumination (per million lumen hour) of approximately 2 in benefit of the first one, this is 5 09 US$/million lm.h (fluorescent 9W) against 9.60 US$/million lm.h (incandescent). Now, if we divided the mentioned period (8,000 h) into 8 regular intervals to be paid by the consumer we will have after 2.5 intervals, a lower cost for the same benefit, illumination, for the consumer who can choose the fluorescent system.

Without any doubt, at first sight, this tacky-economical argument is able to change CFL technology into a very attractive alternative for the replacement of conventional incandescent lamps. But, if we examine some other points, we will surely revise this position Just to mention (as the discussion of these points are not our main objective)

a) necessary time (about 45 minutes) to attain the standard luminous flux;

b) maximum luminous flux is a function of the angle of installation and operating temperature,

c) (strong) dependency of useful life in relation to the number of times it was switched on;

d) control over the rejected mercury after the lamp's use For 200 million lamps/year 5mg mercury/lamp, we will have approximately 187 tons of Hg/year, if these lamps survive 8,000 h, that is 8 times more than the conventional incandescent lamps

In this way we clearly see the necessity of revising the cost of illumination in relation to the usage habit, beyond the concern for clear definitions on the recycling of mercury At present we think it would be convenient to recommend the use of this type of lamp for areas with continuous and uninterrupted periods superior to 6 hours/day (as occurs in the commercial sector)

The CFL lamps with inlaid electronic reactors can be manufactured in Brazil According to the Multinationals, the existing barrier is only due to the low demand of the product in relation to its high cost In spite of this difficulty it is very natural that electronic reactors are used with CFL lamps because of its low losses Electromagnetic reactors can show a loss of 4W, which is very significant when operating with lamps with a consumption of 7W

Besides this, there has to exist a compatibility in the physical size, so that the replacement of the incandescent lamp for the CFL may be easier. CFL lamps with inlaid traditional reactors are much longer, while the use of the electronic reactor allows a reduction in the physical dimension.

The use of CFL lamps encapsulated in glass is also becoming very popular because they are able to simulate better the colours of the incandescent lamps. This product is coveted because the colouring of the incandescent lamp today is better associated with residential environments, with the exception of the service areas in the house. This product already exists in the Brazilian market, imported by the multinationals and sold at a price of US$ 20.

1.3.9 Dichroic lamps

They are halogen lamps incorporated to a reflection system which has the characteristics of reflecting only visible radiation (light) in a given direction and transmits heat in the opposite direction. Therefore, this type of source already has, in an improved way, its "own luminary", emits a cold light, when compared to the conventional incandescent lamp, with excellent colour reproduction. For certain applications it is much more efficient energetically than conventional options.

These lamps are available in 20, 50 and 75W, two-pin base, for a 12 Volts nominal tension (which demands a transformer or electronic converter - both in use) at price of US$ 15 per unity. There exists in the market a lamp for voltages similar to Brazil's grid (code ELH, 300W - 120V), but they are imported and their use is restricted due to their high power.

They have very limited use for decorative purposes, being used almost exclusively by the upper social class who can afford it, with the specific illumination for the room or pieces of art for short periods of time. The reduction of light intensity is common ("dimmer") for the reduction of its work tension. Halogen lamps have a nominal life span of 2,500 hours when operated at nominal tension, for this is the condition for the regenerative cycle to occur. The cycle does not work with tensions below the nominal and in this way durability becomes that of a conventional lamp (about 1,000 hours).

1.3.10 Conventional light fixtures

The use of light fixtures as part of the illumination system with fluorescent lamps is very common in the country, even though there are simpler areas where mere bulbs are used. The conventional light fixtures are

prepared much more to supply an architectonic appearance than to improve the illumination efficiency.

Conventional light fixtures are generally made with iron sheets enamelled with white paint.

The white paint is a guarantee of obtaining a good reflection for the light that comes from the lamp and is directed the upwards. The reflection index of the white enamelled surfaces is approximately 90%, which apparently shows great efficiency

Due to architectonic reasons, and less frequently, due to technical reasons, it is common to use an opaque or semi-opaque material near the base or flaps, also with white enamel The opaque material can absorb up to 50% of transmitted light, while semi-opaque materials of better performance absorb 20%. The flaps also reduce, the efficiency, absorbing and reflecting light to other directions which are not the working area. The architectonic reason is associated to the light fixtures' lack of aesthetics and the technical reason with the possibility of opacity caused by direct light of the lamp concurring with the sight or reflecting on generally mirrored surfaces which may exist in offices

In spite of the opacity only being a problem in working areas, the use of flaps and translucid materials are of common use in light fixtures placed in circulation areas

1.3.11 High efficiency light fixtures

It is possible to prove that light fixtures which are made with the appropriate geometry and with reflective material can supply illumination up to two times higher than that obtained from conventional ones The reason for this improvement lies in the fact that the reflection index which is what really interests in a material, in order to justify its luminous efficiency, is the intensity of the specular reflection and not the intensity of the diffuse reflection Enamelled and white painted surfaces have a high index of diffuse efficiency, that is if measured the light intensity reflected in the whole hemisphere A high coefficient of specular reflection means that almost the reflected light is in one determined direction, defined by the law of optical reflection.

When good reflective material is available, specular reflection takes place, allowing the elaboration of a good geometry with the objective of

diffusing this light to the area of interest. In the case of diffuse reflection, the light which falls on a determined angle is spread in all direction, including th ceiling and the wall, where there is no interest in illuminating.

Optimized geometrical forms may be calculated and some manufacturers already produce these light fixtures in Brazil obtaining an efficiency of nearly 90%, inside a spheric cone of 60 degrees opening (measure between the generating line of the cone and its median line) centered in the fixture and wi its base on the ground. Even though the manufacturers do not totally understand the optimized geometrical form, practical experience and the availability of good quality reflective materials, already allows this type of product to be found in the market.

The reflective material which has been mostly used is the Silverlux film which is imported from the United States and offered in the domestic market for US$ 30 per square meter. It is a film composed of a silver deposit on top of plastic on one of the sides, while the other side is made of a self-adhesive material.

Another product which is available in the American market is the meta sheet on which the manufacturer has already fixed the film Silver deposition demands on sputtering techniques and its price in the Brazilian market may reach approximately US$ 20/per square meter already considering the metallic material

The first option has been used mainly for application on aluminium Other types of material have not offered satisfactory adherence The second option may be applied in aluminium and iron sheets, which is another economical advantage

Besides these two alternatives, anodized aluminium sheets and glass mirrors are also used as reflecting material High reflective anodized aluminiu is not available in the country and the anodization has to be made in small enterprises on demand The procedure has almost no quality control, which means that according to the lot, the quality of the product varies Anodized aluminum reflectors were never produced in this country with the same qualit as those found in the industrialized countries Even though the mirrored glasses are of an excellent quality they have the inconvenience of the weight and high application cost on metals, requiring glue and adhesive tapes as well

as great quantity of labour. The possibility of importing anodized aluminum of great reflective power was considered by the Brazilian Illumination Association (ABILUX) but it never took place.

Some tariff barriers on the institutional side were removed in order to make importation easier. The Executive Group of Energy Rationalization, an interministerial entity, was able to obtain a reduction from 25% to zero of the import tariff on Silverlux film, which allowed its sale for US$ 30/m². Other efforts made in the same direction for anodized aluminum and sheets with applied films have not shown any results yet. The impact of the importation tax on the product's final price is relatively higher than the reduction percentage of the tax because other federal and state taxes are also charged in addition to the service taxes of ports and airports. An estimate shows that a product which is imported in lots at a value higher than US$ 10 000, ends up with a cost 80% higher than the import price, for a custom tax of 25%, after all taxes and services are paid. A reduction to zero of this tax shows a decrease to 45% on the import final price.

In the case of the efficient light fixtures we can see that the information of its existence is known by a small elite since 1990, when a small pioneering competition promoted by the University of Sao Paulo, requested light fixtures with an efficiency superior to 42 lumen/W from the market. This information has been spread since then and there already are some enterprise groups who have demanded the use of efficient light fixtures in their projects for 1992. The main manufacturers are also aware of the product's existence and of its potential in medium term. Some engineering companies are still misinformed and this has provoked great technological inertia.

Regarding production capacity, a profound knowledge of the required geometry already exists in the University as well as some knowledge acquired by some manufacturers by the trial and error method. The sale-persons are still not prepared to sell the product for they have not understood the advantages of the equipment and therefore find it difficult to sell. More advertising of the product is necessary as well as conferences and seminaries capable of attracting project engineering companies.

There are still some difficulties in the case of te[illegible] for the preparation of the material. The technique of metal vacuum deposition by evaporation is practised commercially for the deposition of aluminum in

plastics The ion-sputtering technique is well understood and used in Universities and Research Centers. One of the big light fixtures firms is a multinational enterprise and it has no difficulty in bringing in technology from its headquarters If the other enterprises would be motivated by their competitors they could bring the deposition equipment from abroad and find local expertise and labour to produce them.

The main lack of interest in the production of the reflective material is the small demand market Up to now, reflective light fixtures are sold in quantities of several thousands per year and it is not a big business yet

Another problem which hinders the use of product due to lack of technical competence of the buyers is that they buy the efficient light fixtures because of their appearance and never worry with quantitative tests when choosing or receiving the merchandise This works against technological progress because on one hand it allows that bad quality products be sold, and on the other hand the buyer is not satisfied with the new technology, thus delaying its use

1.3.12 Electric reactors for gas discharge lamps

We think that in the last decade, the first noticeable step towards improvement of the energy performance of the conventional fluorescent system (40W) was the introduction of the switch (bimetallic) placed in series with the filaments and in the interior of the discharge tube of this lamp This resulted in a lamp of nominal power 37W which means that the loss in the filaments (3W) during the functioning of the system stops existing with the interruption of this circuit after the ignition of the lamp Unfortunately the divulgation of this technology has been almost insignificant and only one manufacturer in Brazil produces this type of lamp

Approximately three years ago, this same idea (of disconnecting the filaments) which is able to reduce more or less 7% the power of this type of lamp (40W), was launched in the Brazilian market by manufactures of conventional reactors This innovation consists of an electronic switch which disconnected the coils that feed the lamp's filaments automatically after the start This innovation does not yet have the potential of being rapidly accepted in the market as the first one, for it is destined to new installation and eventual substitutions (the conventional reactors have a life expectancy of 10 years) and has not yet been divulged as expected We believe that the price

difference in relation to the conventional reactor and the lack of consideration for small economies, on behalf of the project engineers, are responsible for the reduced usage of this product.

The first technical developments with views to obtaining the electronic reactor (re) were also started in Brazil at the same time three years ago. There are today at least five manufacturers who have this product for commercialization and we know of others who are still developing it. Some of the prototypes we examined show that:

a) the electric current in the lamps discharge has a frequency above the audio band;
b) the relative efficiency of the system (in lm-W) is located in the band of +20 to 30%, when referring to the conventional reactors (electromagnetic) for two fluorescent lamps,
c) the power absorbed from the network for the same luminous flux is -20% in relation to the conventional reactor,
d) the electric efficiency is superior to 90% against 75% of the conventional reactor,

In spite of the above mentioned advantages, in some prototypes the power factor is still situated around 60%.

1 4 Barriers and possible lines of action

The technology-defined cases described above point towards several major problems/barriers for the market penetration of energy efficient lighting equipment and design Observations made at three professionally oriented seminars during Rio 92 complement and broadly support this early diagnosis.

The problem of quality control in the manufacturing of lighting equipment appears to be widespread This can be seen with lamp lifetimes. Guaranteed lifetimes often do not even exist The past record for many key, already commercial technologies is frequently poor High pressure sodium lamps appear to have a real world lifetime in Brazil of 6,000 h versus a norm of 25,000 h. Much smaller uncertainties regarding this basic parameter can play havoc with any financial/entrepreneurial analysis of additional investment in lighting efficiency. This is not entirely a problem of manufactures' quality control. Maintenance, operations, and uncertainties regarding the specified quality parameters of electricity supply all play a role. Equipment lifetime is also only one aspect of the quality control problem.

The problems of operations and maintenance, not to mention appropriate initial design of lighting systems, make training programs for technology users a high priority. This "human resource" theme will be returned to, because it is central to energy efficiency initiatives in consuming sectors with very different characteristics. The priority need for "education/ training" and accessible information permeates most Brazilian analysis of how to "modernize" the economy. This is partly a consequence of the low standard of Brazilian education, especially basic education, as already discussed.

The problem of overall quality control effects both "conventional" and more advanced/efficient lighting equipment. Advanced equipment suffers as well from a greater relative price differential than is found in industrial countries. This greater differential inhibits a shift towards more energy efficient equipment. Several factors can play a role in creating it. First, the industry is cartelized and has considerable protection for its products. Second, imported components weigh more in energy efficient equipment and may pay tariffs though the reduction of import barriers has been achieved for certain key components Finally, the small size of the market keeps costs high Strategies are needed to break the high cost - high price - small market triangle which particularly limits some technologies. Larger market volume can help reduce costs, opening new segments of demand in a virtuous circle

Several market oriented approaches are worth following Financing mechanisms to reduce first costs appear to be necessary Capital is very expensive in Brazil. It can earn 20% (real) in highly liquid low risk papers People's implied discount rates for personal consumption decisions, are often much higher In addition, many lighting systems are purchased and installed by entities who will not pay the operating bill and who think only of minimizing up-front costs Different mechanisms and institutions will probably be required for different segments of the lighting market At present no line of credit exists for any end-user investment in efficiency

Another, complementary approach, emphasizes increasing the awareness and information available to potential investors while reducing their "transaction" costs in planning and carrying out energy efficiency investments A good example of this approach is the "Green Lights" program created in early 1991 in the U S by the Environmental Protection Agency A variant of this program is being established in Mexico and another is under consideration in

Brazil. In the US program a firm makes a voluntary signed commitment to retrofit 90% of its building area with cost effective (return = 6% above the prime rate) efficiency improvement. In return, it receives free training, software and information on equipment, financing, etc., which help to reduce the "transaction" costs of an enterprise - wide program on a subject generally treated as bottom priority. It also receives favourable environmental publicity, while the same publicity serves to make various publics more aware of the commercial potential of lighting efficiency improvements. The kinds of market imperfections addressed by "Green Lights" are fairly universal, thus the interest in adapting this rather successful program to Brazil. Negotiations have only begun, but it is likely that the program will take a rather different shape in Brazil, even if much of the software and kinds of information are transferred For example, access to financing (not just information) is likely to be much more important; this could, in turn, influence how the audits of cost-effective investments fare carried out. The transfer of "Green Lights" from the U.S to Brazil should provide interesting insights on how market imperfections and their impacts differ in an industrialized and developing country situation. It is also an example of an important kind of technology transfer which involves virtually no hardware

Another market-oriented approach would be to reduce restrictions on the imports of certain components or final products. This need not to be a blanket easing, energy efficiency criteria can and should be used. This kind of measure should facilitate the entry of new more efficient products. This would create an initial market demand which can then "pull" investments in domestic production The difficulty in creating an initial market demand has been a barrier for some technologies discussed above.

Market (or business facilitation) oriented measures must be complemented by "command and control" measures of the government. the most obvious of these are standards for minimum energetic performance Although these have not yet been applied for electricity end use in Brazil, they are regarded as important for some sectors (e.g refrigeration and air conditioning). The application of strictly energetic standards for basic lighting products may be less important or viable However, the whole issue of quality control raised earlier makes norms in general very relevant. Another set of issues bearing on norms and standards involves labelling Most lamps are sized

by their power input and not their luminous output. This led to a surrealistic impasse on labelling norms that contributed to the demise of "energy saver" (first generation)- incandescent bulbs described above. Implicit in labelling programs or the establishment of norms is the existence of neutral laboratory facilities for monitoring performance of different products.

Another set of "command and control" measures involves government regulation of the electric utility sector. The need for regulatory reform, part of a wider change in the institutional/ financial model, is recognized as urgent, though negotiations have been complex and slow. Reform is likely to be necessary if utilities here are to make significant investments in end use efficiency and firmly incorporate "demand side management" (DSM) into their service expansion strategies. Distribution utilities especially feel little financial incentive to promote DSM. International experience suggests that active utility led DSM programs can make an important contribution to overcoming market imperfections. In the U S. they were crucial to the consolidation of "Energy Service Companies" (ESCO's) though DSM doesn't necessarily imply ESCO's. These new intermediaries help reduce the transaction costs and risks of energy efficiency investments.

ESCO-type companies exist in Brazil, but their market is still very precarious The consolidation of this kind of service could contribute to easing market acceptance of lighting another efficiency improvements in the commercial and industrial sectors Utility led DSM is still very limited in Brazil. While regulatory reform is ultimately necessary, it would be a mistake to paralyse SM while waiting for this unpredictable process to reach a conclusion There is a great need for pilot programs to develop and test various measures

So far electricity pricing has not been discussed The average electricity tariff in Brazil is substantially below the marginal cost of supply There is an important school of thought coming out of neo-liberal economics which believes that if the price were brought up to the marginal cost, optimization of demand would occur almost automatically with a helping hand from trade liberalization Most measures raised above are of little or no value in this view The authors do not agree with this school's diagnosis. Full cost pricing is neither a necessary nor a sufficient condition for achieving much cost effective energy efficiency gains Obviously, it is desirable that prices reflected full marginal

costs (including externalities) and higher prices will clearly help viabilize additional energy efficiency gains. However, even with the existing inadequate tariffs many efficiency investments are cost-effective (3). Furthermore, in at least two sectors of demand (low-voltage commercial and larger residential) existing tariff levels equal or exceed the marginal cost These two sectors also offer a rather effective rebuttal of the purist neo-liberal view that full cost pricing is sufficient to stimulate an optimized demand adjustment. By this view, the efficiency of energy consumption in these two sectors should be markedly better than in the rest. There is no evidence that it is. Either consumers are magically correct letting opportunities to earn returns of 30%, 40% or more pass by or there are serious market imperfections at work We believe that the latter alternative is more reasonable and far abundantly documented. The measures discussed above are attempts to address these market imperfections This does not mean a blank check for a philosophy of government intervention The measures proposed have the objective of helping the market adjust closer to the new optimum suggested by the electricity price signals. The kinds of measures being discussed should be regarded as a key complement to pricing policy, partly in order to help it work better, partly in order to make the large necessary increases in average tariffs politically acceptable. This latter point is very important and has not been adequately considered If prices were easy to increase to desired level by government decree, that would have been done long ago The World Bank has been pressuring Brazil's electrical sector ever harder on this point since 1984, and power sector loan negotiations have been discontinued as a result

Any discussion of pricing and of utilities' supply/demand strategies in Brazil cannot ignore the importance of inflation, the uncertainty regarding when and how a sustained economic recovery will occur after a dozen years of stagnation, and the near certainty that any recovery will quickly hit the limits of electricity supply. Brazil is a country with a long history of high inflation This history generates a culture For example, businessman quickly reckon (correctly) that at moments of increasing inflation the government can be relied on to hold back on electricity tariff increases, as is occurring again now. This short-term signal influences priorities By-and-large the effects of a "high inflation culture" are inimical to energy efficiency improvements, or indeed any major productivity - enhancing investments in industry and commerce Firms

dedicate disproportionate senior management to short term financial intermediation. Consumers find it difficult to do more careful "comparison shopping". Successive macro-economic shocks to bring down inflation add to the uncertainty which complicates and inhibits investment decisions.

The hibernation of Brazil's fundamentally dynamic economy since 1980 has permitted the country' state-owned hydro-electrical sector to usually satisfy demand without any rationing except for two brief occasions - 1978 and 1986 in the Southern Region of Brazil, and in 1979 and 1987/88 in the area reached by the North-Northeastern Grid. This relatively good performance of a state-owned infrastructure sector in an extremely adverse business climate has probably lulled Brazil's key political and business decision-markers into a false sense of security regarding an extrapolation of business-as-usual behaviour However, among strategic thinkers in the electrical sector the consensus is different. Unless measures are taken soon to advance Brazil up to the learning curve to exploit its large potential for electricity conservation and private sector investment in generation, it would be physically and financially almost impossible to meet the electricity service requirements of a sustained and rapid economy recovery, though San Pedro's rains are an element of uncertainty. This convergence in the definition of the problem among diverse professionals in the electric sector has lead to the creation of the only NGO in Brazil focused on addressing it. The existing institutional channels for catalyzing such wide ranging changes were felt to be inadequate. This new kind of entity is appearing under various guises in Eastern Europe, the ex-Soviet Union, and other Latin American countries, though there are important differences in priorities and styles Will they be able to contribute significantly to improving energy efficiency? In Brazil at least there is a belief that such an entity can make a difference, catalyzing and leveraging larger investment flows and helping to create markets for relevant services In the search for responses to the challenge of more rapidly introducing energy efficient technology in developing countries, the role of such NGO's and possible offspring should be tested, stimulated and monitored

1 5 Conclusions

There is a very large theoretical cost-effective potential for energy efficiency savings in lighting. The rate of penetration of improved technology will depend on policy towards electricity tariffs and whether market barriers

which inhibit economically efficient consumer adaptations are effectively addressed. The realization of the former may depend on progress in the latter. Achieving the latter will require creativity and change. These change from independent and transparent regulatory organs of the government, to private companies specializing in new market services (including subsidiaries of utilities), to NGO's.

Within the context of invigorating policy towards energy efficiency overall, lighting is an interesting early priority. The end-use equipment is relatively short-lived. This means that changes in the profile of new equipment sales can more quickly influence the energy profile of the operating stock of lighting equipment than is possible in most energy consuming sectors. Also, while there are millions of consumers of lighting equipment, the manufacturers of basic equipment are few and it is possible to define market segments. This simplifies policy-making. Furthermore, light is highly "visible". These characteristics together make energy efficiency in lighting an excellent target for a multifaceted program which can begin to show palpable results in the relatively short-term and can also have an impact on various publics' awareness of the potential of energy conservation and how to do it This is a basic premise of the "Green Lights" program in the USA, discussed above, which may be interesting to explore in developing countries

The relatively slow penetration of more energy efficient technology and system in the lighting market is a result of factors on the supply and the demand side On the supply side this report has raised pervasive problems of quality control and larger price differentials between conventional and more efficient lighting equipment. An approach to both problems involves liberalizing imports of final products and components Technology development and acquisition do not appear to be bottlenecks in the lighting sector, though the costs of technology acquisition were not fully analyzed in detail for this report.

While supply-side problems exist, the most important drag on penetration has been the lack of demand "pull" for new products. The lack of demand volume helps maintain equipment prices high. Various studies have shown that very high returns can be gained on many investments in lighting efficiency, even with existing unsustainably low tariff levels. The report presented some of the major barriers to realizing this potential: financing, information/ awareness, transaction costs and the lack of skilled service

intermediaries. Some initial lines of action were sketched out. Brazil is well down the learning curve for these kinds of measures. For example, the only public sector credit-line for energy efficiency was recently cancelled for lack of applications. It is an urgent priority to start launching a series of pilot programs.

It will be very difficult to fully finance these pilot programs domestically, even though their requirements are small relative to supply investments. The government cannot escape its deficit, inflation remains very high, the utilities are in financial crisis. There is a very strong case here for catalytic international financing, especially from the multilateral development banks, the IFC and the GEF. There have been, however, strong impediments to such financing. In the case of the World Bank, the priority is to pressure for closer approximations to the full marginal cost of electricity supply. Adequate operational mechanisms to finance end-use efficiency projects are not yet in place. There may be changes as a result of an internal review of the Bank's role in promoting energy efficiency which is currently underway. The Bank has in any case not made any new power sector loans to Brazil for some time, since the government's commitment to increase average tariff levels has not been fulfilled. One way out of this impasse might be to finance a package of structural adjustment measures - such as energy efficiency, utility DSM programs and private sector power generation and cogeneration - which can create and improved climate for achieving and maintaining adequate electricity tariffs, among other things.

In the case of GEF (Global Environment Facility), the criteria for project approval have so far been highly unfavourable for the most interesting energy efficiency programs These generally have relatively high economic returns, whereas the GEF is supposed to finance low-return projects in order to bring returns up to an acceptable level As a consequence the GEF has had to downplay the most promising area for CO_2 abatement in energy Interpretation of these criteria has gone back and forth during the GEFs pilot phase It is to be helped that with the GEFs consolidation of Rio-92 a compromise can be settled on that allows financing of innovative energy efficiency programs. Perhaps greater emphasis should be placed on market barriers rather than on the projected economic return of a successful program.

Whatever the source, external financing can accelerate the consolidation of a policies to overcome market barriers to energy efficiency improvement and the diffusion of new technology. The returns should be adequate to attract increasing levels of local financing.

2. Cogeneration technologies in Brazil - Potential and limitations

2 1 Introduction

Cogeneration is defined as being the production of electricity and usable heat from a single thermodynamic machine

Oportunities to increase the supply of electricity through the use of central power stations are being reduced due to escalation in investment costs, and the concern with environmental degradation, locally or at global level, which is always associated with more energy production(4) Decision makers are becoming more interested in the use of energy with high efficiency One way to save energy is through the development of cogeneration plants by industries which use significant amounts of thermal energy for process heat or for space heating and cooling Electric generation through a thermodynamic cycle always produces heat as a by product, if this heat can be used we have the potential to produce considerable fuel savings Obviously central power plants also have the possibility to operate in a cogeneration mode, where the waste heat is sold to residential customers for space heating or to industrial customers for space heating or as process steam This case requires installation of a steam distributing network in cities, which implies a large investment and is more suitable for temperate countries In this paper we will not discuss this technology

In this paper we divide the discussion according to the final use of the heat produced Under item 2 2 we present the possibility of using heat as a source of more electricity In item 2 3 we discuss the option of direct final use of steam and in item 2 4 the particular case of using heat as an energy input for cooling air Item 2 6 deals with the possibility of using the new generation of gas turbines for cogeneration units Items 2 5, 2 7, 2 8, and 2 9 deal with specific cogeneration applications in Brazil and their consequences. It is not our intention to present all their possible cogeneration schemes according to the final use of the heat, as well as We have only selected the most important cases in the Brazilian context

2.2 Cogeneration for central power stations

The cost escalations that have made coal-fired steam electric plants expensive and have essentially killed nuclear power as an option for new construction in the foreseeable future in the United States are due in part to tightening environmental and safety rules.

Figure 1 shows that in the United States the electricity price had been declining from 1935 up to 1973. After the oil shock, prices increased. Even after 1982 with a decrease of 70% in oil prices, the average electricity price has declined only 4% (5). The main reason for this price increase should not be attributable to the price of fuel, but to the fact that the capital costs of central station power plants have escalated dramatically.

Electricity rate increase and the Public Utility Policies Act of 1978 (PURPA) have led to a competitive challenge for utilities from independent cogenerators and small power produces. PURPA requires a utility to purchase electricity from cogenerators and other qualifying independent power producers at a price equal to the utility's avoided cost.

The greatest challenge to utilities from cogeneration comes from the steam-using basic industries, where the economics of cogeneration are the most favorable. Under this condition in 1987 the Federal Energy Regulatory Commission in USA began considering establishing a scheme to allow competitive bidding for utilities incremental power requirements, a scheme that would allow cogenerators, small power produces, other independent power produces, and utilities to compete on the same basis(6).

To compete with cogenerators utilities have to exploit the possibility of improving the efficiency of traditional steam-based electricity generation or to search for alternatives that will allow them to use the produced heat as a source of more electricity. Unfortunately the possibilities for improving efficiency of steam-based plants are not good. The efficiency of modern fossil fuel-fired, steam-electric power working at steam pressures as high as 24MPa and temperatures of 540°C, has not improved since the late of 1950 when such peak steam temperature were reached. Under such conditions, as shown in Figure 2, the maximum net efficiency of a steam plant does not surpass 40%, which is quite low as compared with the full energy efficiency reached by cogenerators, which easily reaches 80%.

One possible alternative is the use of combined cycle technology. Combined cycle technology is familiar to the electric utility industry worldwide. In a combined cycle,a gas turbine produces mechanical energy to rotate an electric generator and produces heat in the form of hot air exhaust that is used to heat water and produces steam which drives a conventional steam-based electric generator. The interest in this technology has increased in the last 10 years, since gas turbines have become almost as efficient as the best steam turbines. Up to the early 80s, the historical attraction of gas turbines for utilities has been its low cost of $300 per kW(7) or less, a small fraction of the cost of coal or nuclear plants(5) Simplicity has been the major- target of gas turbine constructors and even though the turbine inlet temperature is high in a gas turbine (1100°C compared to 540°C in a steam turbine), the efficiency has been less than 30% This constraint associated with the cost of better quality fuel (natural gas, kerosene or diesel oil) limited the gas turbine in utility applications mainly to peaking service

More recently several improvements in the design of gas turbines, mainly smaller sizes of the aeroderivative type, have significantly increased efficiency For example, a combined cycle was put into operation in 1986, for the N V Ijsselcentrale, a Dutch utility company with a gross power efficiency of 50%(8) The plant uses 2 LM2500 gas turbines, one steam turbine and the electric generator coupled together through only one axis. Power output of both gas turbines is 42MW with a gross efficiency of 35% while the steam turbine provides 18MWe, allowing a gross power output of 60MW Total natural gas consumption is equivalent to 119MW, yielding a gross efficiency of 50%. This system has a remarkable efficiency but due to the use of a small size steam turbine has a price per kW above US$1000 00, as shown in Figure 3

Other improvements have achieved high efficiency with a price per kW very much the same as the gas turbine single cycle gas turbine The improvements allow the use of the heat released with the exhaust gases to produce steam which is injected back in the combustion chamber of the turbine. These units called STIG are being used in commercial applications and there are 30 units in operation, construction or under order in the USA alone The largest unit commercially available is based on the GE LM-5000 turbine (used in the Boeing 747 airplane). As a simple cycle it produces 33MWe at 33 percent efficiency when operated on natural gas fuel With full steam injection this

engine produces 51MWe at 40 percent efficiency. Turnkey STIG units of this capacity packaged on a skid and without a building are commercially offered for about $700/kWe(9).

Another alternative to steam-based power plants is to use the evolving technology of combined-cycle. For example the GE LM- 6000 which should be in the market in 1992, will produce 42.4 MWe at a simple cycle efficiency greater than 36 percent using natural gas and will have an estimated gen-set equipment price of $250/kWe(10). Combined cycles based on the LM-6000 are expected to produce 53.3 MWe at an efficiency of 48 percent(11).

Obviously such remarkable performance is attractive but the total electricity generation efficiency is not above 50%, which is low compared with the 80% efficiency obtained when steam and electricity can be simultaneously used as end applications(8). Nevertheless central power station with such efficiency are able to compete with steam and electricity cogenerators, because electricity has a higher value as compared with steam.

2.3 Steam and electricity cogeneration

This is a well known commercial practice. Almost all producers use a steam - Rankine cycle, a technology 100 years old.

In general the higher the peak temperature of the working fluid the higher the thermodynamic efficiency of a power- generating cycle. Most of the units are of small size (up to 30MWe) as compared with central power station (200MW and up). Due to the small size, economy of scale imposes high investment cost per kW, as shown in Figure 3, and also limit the maximum achievable electricity efficiency Such units when designed only for power production have efficiencies of 14 to 18 percent in California(12) and from 10 to 16% in the North of Brazil as shown in Table 1 (13)

Such levels of power generation efficiency are achieved with a fully condensing turbine. When large amounts of steam are produced, the power generation efficiency can be as low as 5%, as is very common in sugar mills in Brazil(14). Such low efficiency is the main reason why small scale electricity production is not understood as a good business for large entrepreneurs

2 4 Air cooling and electricity cogeneration

This is another technology well known for several decades, but only in the last few years has it become the object of commercial interest Air cooling

can be obtained with absorption pumps that use hot air or steam as the provider of energy input.

Absorption cycles use a vaporizable liquid, for example ammonia, as a refrigerant and a second liquid, for example water, as an absorbent for the first. A schematic diagram of the flow process involving both the water and the ammonia is shown in Figure 4. The right-hand size of the diagram is identical to the condenser-evaporator arrangement of a device utilizing vapor compression, cycle, except that there are no longer a compressor and a throttling valve linking then. Instead, heat energy is used to drive an absorption-generator unit which effectively acts as a compressor. The ammonia circulates completely around the circuit, that is from the evaporator through the absorber and generator to the condenser, whereas the water only circulates between absorber and generator

In the condenser the ammonia loses heat and condenses The liquid ammonia is passed through a flow valve to the evaporator Here the pressure is sufficiently low for evaporation to occur, the latent heat being extracted from the evaporator surroundings. The ammonia vapor enters the absorber where it is absorbed by the water with an accompanying release of the heat of solution The concentrated solution can now be passed easily to the high-pressure region of the generator using a pump (As the absorption process has effectively "compressed" the volume of vapor this is not a compressor, but merely a circulating device requiring little energy(15)). In the generator the water and ammonia are again separated using heat energy as the energy present at exhaust of a thermal equipment. The water flows back to the absorber via a flow control valve and the ammonia vapor passes directly to the condenser Thus the absorption refrigeration cycle is essentially a heat engine and a vapor compression cycle combined The technology allows the same energy service as the conventional electric pumped cooling system with one only fourth of the electricity consumption and with the significant environmental advantage of avoiding the use of CFC gases, since it uses ammonia or lithium bromide as the cooling agent

In this circumstance small scale electricity generation can be performed in a thermodynamic cycle and the heated exhaust air can be used directly in the absorption pump or indirectly through the production of steam Commercial cooling system are lower than 5000 TR per hour which is compatible with the

generation of less than 10 MW of electricity. Due to the small size, as compared with central power station, the economy of scale in the investment is an important adverse factor.

Absorption air-cooling systems are being installed in USA in systems that use gas turbine or diesel engines for the generation of electricity. Gas turbines are less efficient than diesel engines for this range of size but have a longer operational life. Initial investments in the USA are very similar for both options, but this is not the case in Developing Countries. Diesel engines are an old technology and some Developing Countries have the capability to produce or to assemble such engines. Gas turbines are a new technology for them and almost all the equipment has to be imported with a consequent increase in price due to taxes, transportation and outside assistance.

2.5 Case studies for Brazil

Thermoelectricity is responsible for a very small fraction of electricity generated in central power stations in Brazil. There are a few coal based steam turbines being used in the southern state of Rio Grande do Sul. Such units are of small size as compared with the international market (around 300MW per unit) and the total installed capacity adds up to 1500MW. The efficiency is not good (28% in average according to ref. 16) and they have to compete with hydroelectricity since they are connected to the major grid system which links the South/Southeast and the Centerwest of Brazil.

There are three other medium size oil-fired steam turbines units (500 to 200 MW) in operation in Southeast of Brazil They also complement with hydroelectricity and in years of normal rainfall they are used less than 10% of the time, a little less than the coal-based stations which run with a load factor of 20%, under the same circumstances(17)

In Amazonia there is more space for thermoelectricity Isolated systems are mainly supplied by single cycle gas turbines using a blend of light fuel oil/diesel or diesel engines coupled to generators(18)

On average thermoelectricity supplies only 4% of the total electricity demand(16).

It is only in the last 6 years that interest in the installation of more thermoelectric units based on fuels other than coal has appeared For central power stations the largest project being considered is the installation of a 450MW complex fueled with natural gas from Bolivia and which should be

installed in Bolivia, near the frontier with Brazil, for the purpose of exporting eletricity to the South/Southeast/Centerwest linked grid(19). The project was object of a contract between Brazil and Bolivia and the interest of Brazil is in the reception of the electricity and not with the technology used. There is no clear information about the equipment that shall be used but some information(20) claims that single cycle gas turbines may be used.
Another project under discussion is the proposal of the Companhia Energetica de Seo Paulo to install two steam-based thermal plants (700MW and 350MW) near oil refineries to run with very heavy oil(16,18). Another possibility is the proposal to convert the oil-based steam thermal plant in Seo Paulo state (475MW) to a combined cycle, with the additional installation of gas turbines This project would require an investment of 1 billion dollars and would increase the plant output to 1200MW (22) This proposal has been much criticized, since the existing plant is 30 years old and was designed to use high pressure steam (110bars) which will not be used in a combined cycle

A program which is being seriously executed is the production and exportation of electricity to the grid by the sugarcane industries. The sugar and ethanol mills, installed in large numbers (359 units in (23)) to supply the Programa Nacional do _lcool (PNA) since 1975, were designed to use very simple technologies, including that for the production of electricity and steam. Since the begining of the PNA, mills were equiped with steam boilers fueled mainly by sugarcane bagasse and, when necessary with wood. Low pressure steam is required in large amounts for the production of sugar and as much as 500 kg of steam is consumed during the processing of one tonne of sugarcane. Since steam has to be produced for the distillation process, most of the mills were designed to produce steam at a pressure of 21 bars, which means that this medium pressure steam can be used initially for providing mechanical power and the low pressure escape steam for heating the distillation columns Up to a few years ago, there was no reason to be efficient since the surgacane residue had little or no value. Low efficiency boilers are able to provide up to 20 kWh/TC and 500kg of steam per TC, which is enough to run the processing plant (20)

Technology is available for the production of much more electricity per tonne of cane (TC) A recent evaluation carried by Eletrobras and Copersucar(24) concluded that steam turbines burning sugarcane bagasse can

produce as much as 83 kWh/TC, as well as, all the steam required for the sugar and/or alcohol processing.

The study investigated six alternatives to enhance electricity production from sugar mills in Sao Paulo state. The simplest one is the reduction in the amount of steam required for sugarcane processing. Steam reduction from 465 kg/TC up tp 332 kg/TC were analysed as feasible. Alternative 2 proposes cogeneration with steam extraction at the limit of steam pressure required for the process, using boilers from 21 up to 80 bars of pressure. Alternative 3 foresees the use of condensing-extraction steam turbines with the use of 100% of the bagasse and other sugarcane residues during the season, with steam pressure of 21 up 80 bars. Alternative 4 is the same as 3 plus the burning of biogas produced from stillage fermentation. Alternative 5 is the same as 3, plus the burning of dry stillage and Alternative 6 deals with a complete different technology - gas turbines (see section 2.6). Investment cost ranges from US1300 to US$1800 per kW produced using steam turbines, which means that an investment of up to 20 million dollars is necessary to take full advantage of the efficient use of the sugarcane bagasse and residues available in a mill processing 300 TC/hr (650,000 l/day of ethanol during the season). This is a significant investment since a conventional mill of this size requires a total investment of about 40 million dollars The increment in investment is high but the study concludes that further electric generation is cost effective if electricity can be sold to the grid at US$55/MWh (48US$ for the generation and 7US$ for the avoided transmission investments). Total electricity production from sugarcane and residues using steam turbine technology can be as large as 19.2 TWh or about 10% of the total electricity consumed in Brazil today.

2.6 Advanced technology status

Another possibility is the use of gas turbines using sugarcane bagasse and residues as a fuel This technology requires gasification of biomass, as a front-end process, to provide the adequate fuel to the turbine. There are no commercial installations in the world based on this technology but research is under way and projects are being developed to use its potential

Biomass gasification, like coal gasification is by no means a novel concept, as, fuel gas has been manufactured from coal for some two centuries. Throughout the nineteenth century and well into the twentieth, the most familiar fuel gas was "town gas", a combustible mixture of hydrogen and carbon

monoxide produced from coal, used for lighting and cooking. After 1950, the most successful fuel gas has been natural gas and its upsurge has been a key reason why some markets for coal have dwindled. In the 1990s, although the competition from natural gas has became even more intense, fuel gases from coal and biomass are gradually edging back into contention.

A variety of large scale coal gasification units have recently been assembled and become operational. In 1975 British Gas (UK) constructed a commercial-scale prototype gasifier in Westfield, in Scotland. The reactor operates at high pressure (23 bars) and uses pure oxygen and steam to gasify 550 tonnes-per-day of coal The performances has been quite good and the unit was used mainly as a test bed for different trials for various applications. A Rolls-Royce SK 30 gas turbine was installed in 1986 and supplied electricity to the South of Scotland Electricity Board.(25)

The international oil company Shell began its own coal gasification program in 1972 A large experimental unit, with a capacity of 150 tonnes-per-day started operation in 1978 at Shell's Hamburg refinery in ex-West Germany It operates at 23 bars and also uses pure oxygen. A full scale commercial demonstration unit was completed in 1987, at Shell's Deer Park facility near Houston, Texas, with a capacity to gasify 250 tonnes per day of bituminous high-sulphur coal. The unit is in operation and according to EPRI it has met and exceeded all environmental requirements Shell has always been interested in the production of electricity as an end-use of the fuel gas. Thus it decided to install, at Buggenum, in the Netherland's a plant able to gasify 2,000 tonnes per-day of bituminous coal for generating 285 MWe, from a gas turbine generator and 130 MWe from a steam turbine generator (combined cycle) Net efficiency of the plant should be 43 2 percent (25) The plant is due to start up in 1993 and from Shell's experience they believe that a new commercial unit with 400 MWe will cost US$1400-1500/kW (1990 US$ dollars)

Texaco is also very interested in the electricity generation business and its gasifier designed was used as part of the Cool Water project. Under this project 1,000 tonnes of coal per day was gasified at high pressure, using oxygen and a combined-cycle power plant. An EPRI study published in late 1987 suggested that electricity from a mature commercial plant with the same technology would be able to sell electricity 10% cheaper than from a conventional coal-fired plant with the same emission quality The planned

experimental programme was completed in 1989 and was shut down, since its overall fuel efficiency was only 32 percent and it could not compete economically with other generating capacity available in the region.(25)

Dow Chemical Company also has a coal gasifier in operation in Plaquemine near Baton Rouge, Luisiana. The gasifier feeds a combined cycle power plant which generates 161 MW of net power. The gas turbine runs with producer gas, natural gas or blends of both and has been able to comply with federal environmental standards.(25) Other projects are under consideration, using similar technology or adding major breakthough like the one proposed by H & G Engineering and candidate for installation at the Nynas Energy Chemical Complex AB, south of Stockholm. The breakthrough is the passage of the hot producer gas through a water quench, and then into a so-called "shift expander" to promote the "shift reaction": $CO + H2O - CO2 + H2$. This is an exothermic reaction which reduces the steam content of the fuel gas avoiding water condensation during gas expansion and the temperature increase raises the pressure enough that the gas can be fed through an "expander", like the turbine stage of a gas turbine producing extra electricity.(25)

Biomass gasification, in principle technically more easily achievable than coal gasification(26), is not so well developed. The major reason is that until recently biomass was envisaged as a low quality fuel, with a tendency for its participation in the primary energy matrix to decline, as countries develop. Commercial biomass was poorly used and non- commercial biomass was important as a source of energy only in the Third World, where technical competence and financial constraints impose serious limitations for development of new technologies Important differences with respect to coal gasification are the use of air-blown instead of oxygen-blown gasification and probably the use of a steam injected gas turbine instead of a combined cycle The sensitivity to scale costs of oxygen plants and conventional combined cycles recommends the other options (see Figure 5). Also, while the gas exiting the gasifier must be cleaned, so doing would not require developing advanced hot sulfur removal technologies (as required for coal), because most biomass contains negligible sulfur. Furthermore, the looser molecular structures of biomass compared to coal makes it more reactive and easier to gasify (see Fig. 6) so that fixed-bed and fluidized-bed gasifiers, which operate at lower average

temperatures than some of the gasifiers used for coal, can provide essentially complete carbon conversion and high gasification efficiency.(27)

There are four major projects under development to make Biomass Gasification Gas Turbine (BIG/GT) a commercial product. Ahlstrom, a Finnish producer of biomass gasifier plans to build a 6-10 MWe BIG/GT cogeneration demonstration plant in Sweden(28). The gasifier should be of the pressurized fluidized bed type, and starts operation in 1993. The Department of Energy in the U.S. has selected one pressurized bubbling-fluidized bed gasifier developed by the Institute of Gas Technology to be assembled in Hawaii, using sugarcane bagasse.(29) Initial operation is scheduled for 1993. Also in the US the Vermont Department of Public Service was quite active in 1990/1991 overseeing the installation of a gasifier and a gas-turbine unit that would use wood residues as fuel Under this project General Electric carried out a complete experiment on the compatibility of the gas fuel characteristics and the performance of the gas turbine simulator.(30) The fourth project is described in the next item.

2.7 Advance technology in Brazil

In Brazil a consortium of private and public companies prepared a proposal to build a wood gasifier coupled with a gas turbine to produce 20 to 30 MWe The project received a grant from the Global Environmental Facility (GEF) and is presently in Phase II, which is the detailed engineering project and the removal of major technological bottlenecks (small modifications on the gas turbine to run with low BTU-gas (1000 kcal/Nm3) and the choice of the appropriate gasifier and gas clean-up system able to provide fuel gas under the severe specifications of the gas turbine manufacturer) The Phase II of the project should be completed in 94 and if a successful detailed project can be prepared, US$23 million is available, as a GEF grant, for its construction Total cost is being estimated around US$2500/kWe for the first demonstration unit(31) Which means that total investment cost for the generation of 20MWe will add to US$50 million, with the balance of the money provided with capital from the involved companies (Shell do Brasil, Companhia Vale do Rio Doce, Companhia Hidrelitrica do Seo Francisco and Eletrobras). General Electric is preparing the gas turbine modifications and Bioflow, a Finnish Consortium of the Ahlstrom and Skydkraft companies, and Studvick, a Swedish company, are designing two different gasifiers (32)

A recent evaluation carried out by the major ethanol producers organization in Brazil (COPERSUCAR) and the Electric Sector Board (Eletrobras) concluded, after analysing 6 different alternatives for electric power production (see section 5), that the gas turbine alternative requires less investments and allows the production of 40% of the total electricity consumed in Brazil in 1991.(24)

Advanced technology is also being used in Brazil for cogeneration of electricity and air cooling. An installation using such technology was completed in a Shopping Center in Rio de Janeiro, using a Caterpilar gas turbine and an air cooling absorption pump. A project is under development for a large office area of the Banespa Bank in the city of Seo Paulo. To provide air cooling to 240,000m2 of space, a system with a total heat capacity of 4000 TR fed with the heat exausted by a set of two 3MW gas turbines (6MW) should be used.(33) Another Shopping Center under construction in Sao Paulo is interested in the technology. A pre-feasibility study concluded that the total cost for the installation of 1800 TR plus the generation of 3000 kWe would reach US$4-6 million.(34) Even with the lowest price of natural gas (13 cents per Nm3 under a take or pay contract), the payback period would be 4-7 years, which is long by private entrepeneurial criteria. The reasons for the poor economic feasibility are a) the technology is very new and the first units will be more expensive; b) electricity during off-peak hours in Brazil is low (4 cents/kWh) and even charging heavily on price during the peak period the average cost is low (8 cents/kWh) for users that buy power at middle voltage (13 8kV)

2.8 Institutional issues in Brazil

The interest of the public authorities in the use of cogeneration is growing Shortage of public money to expand the supply of electricity is the major motivation A recent document prepared by the Secretary of Science & Technology of the State of Sao Paulo(35) claims that cogeneration using natural gas as a fuel is reliable, less costly than adding of new central power station, requires a short time to be operational, can be installed near the major consumers in the cities, has good efficiency, and causes less impact to the environment.

Another document(36) raises several institutional issues that must be solved to stimulate cogeneration

Tariff rate - the acquisition price of excess electricity sold to the grid should be object of negotiation can not be lower than US$42 per MWh and nor higher than the long term marginal cost of the interconnected grid system (presently around US$53/kWh).

Continuous supply - Since most Brazilian electricity is supplied from hydro sources, the major utilities would like to sell their energy as base load and to rely on private cogenerators only during the dry season and/or critical rain years. This situation does not favor private producers and does not fit the profile of electricity generated by them. Thus minimum load factors should be guaranteed in contracts to foster cogeneration.

Existing legislation - The first regulation about private cogenerator set by the Federal Control Board (DNAEE) is from 1981. Since than few contracts were signed Further regulation has been issued but they do not guarantee minimum load factors and there is no clear methodology for the definition of avoided cost on central power station construction due to electricity supply by cogenerators. Also the time horizon of contracts is not regulated in order to guarantee return on investments.

The necessity for regulations more favorable to cogenerators is obvious The potential for natural gas based cogenerators is very significant. A conservative estimate based on data from 1985(35) claims that 13 TWh (6 5% of the electricity consumed in Brazil in 1991) could be produced Cogeneration potential by the sugar/ethanol industry can be as high as 100 TWh.(37)

Even in the existing difficult context, cogenerators from the sugar/ethanol industry are selling excess electricity to the grid The largest supplier (Companhia Agucareira Vale do Rosario) sells to the grid 2.3 MW during the season, at a price of US$21/MWh. The surplus electricity is derived from sugarcane bagasse burned in a 21 bar steam boiler An agreement between the three major utilities of the State of Seo Paulo will set the acquisition electricity price equivalent to the long range marginal cost The cogenerator is willing to invest US$2 5 million to upgrade the boiler to 42 bars and then sell 5 MW if the price is adjusted between US$45 and 55/MWh (38)

2.9 Environmental issues

The principal greenhouse gas (GHG) of which Brazil is an important contributor in the world is CO2 and the largest source of CO2 emission in the country is from clearing of forest land for other uses Despite the

preponderance of deforestation on CO_2 emissions it is important to search for possibilities of its reduction from fossil fuel.

Total CO_2 emission from the combustion of fossil fuel in 1990 reached approximately 57 Mt of C. (39). To this value we have to add CO_2 produced from biomass when burned for energy production. A rough evaluation(39) suggests that 9Mt of C has to be added to the earlier figure yielding a total C emission of 66 Mt in 1990.

CO_2 emissions for electricity generation in Brazil are very low as compared with other developing countries; and is about 9 kg C per MWh against a world average of 170. Thus the impact of a change in the profile of the electric sector, due to the introduction of thermal central power stations or cogenerators, even if they represent a significant change at the margin of the electricity profile, will be negligible for a long time. Even so, if it is possible to develop a policy that will fulfil other major requirements and can be less aggressive to the environment, it should be pursued.

Cogeneration can be practised in Brazil with a net benefit to the environment. Industries in Brazil (see Table 1) used 8.0 Mtoe of oil and 4.9 Mtoe of firewood With cogeneration, mainly performed with natural gas, we should observe a decline in the amount of fuel oil and firewood consumed. Remembering that fuel oil has an emission rate of 72.6 t of CO_2 and natural gas only 50.6 t of CO_2 per 1012J of burned fuel this substitution implies CO_2 abatement. Also the present use of firewood plays an important role, since around 50% of it is due to deforestation(39) contributing to CO_2 emission Firewood based industries will not be good candidates for cogeneration, because of instability of supply and growing public and private awareness against deforestation Sugarcane bagasse on the other hand is a very good candidate to be used by cogenerators of the sugar/ethanol industries Being a complete renewable energy source its agression to the environment, through CO_2 emission, is zero.

Another reason to believe that overall CO_2 emission from cogeneration will not increase above the present industrial level is the necessity of improving the fuel efficiency if these units are expected to be cost effective against electricity supplied by the grid The high technology being offered world widely for generation of electricity is always concerned with reduction of local and global pollution (4)

Table 1.

CITY	UTILITY	CAPACITY MW	INVESTMENT US$ MILLION	EFFICIENCY (%)
Cruzeiro do Sul	Electroacre	6	18	13.6
Tarauaca Feijo	Electroacre	3	8.7	14.6
Sena Madureira	Eletroacre	1.5	4.5	14.6
Guajara	CERON	6.2	17.5	13.2
Boca do Acre	CEAM	3	8.7	16.2
Carauari	CEAM	3	8.7	16.2
Eirunepe	CEAM	3	8.7	16.2
Ariquemes	CERON	8	20.7	9.7

2.10 Conclusion

Cogeneration is an excellent opportunity to improve efficiency in the use of energy. Due to several difficulties the state owned electric sector is starting to accept cogenerators as one possible solution to attract private capital for infrastructure investment. Cogeneration is being commercially practised in the United States and several projects are being implemented in Brazil, where a few cases are already in operation. The largest potential cogenerator has been identified as the sugar and ethanol industries followed by other industrial activities which use large amounts process heat. The first candidates should use sugarcane bagasse and field residues as the source of primary energy and the other potential industries should rely on natural gas. Renewable energy sources like bagasse will help to improve the quality of the environment at a global level and should be rewarded by that through grants or preference form international financing. Natural gas, will replace fuel oil in the potential cogenerators' industries with also a positive impact on the environment at a

global scale, since its CO_2 emission is lower than oil for the same amount of energy consumed(39).

Finally it is important to observe that the valorization of biomass as a source of energy is the only way to avoid deforestation. The development of commercial biomass gasifiers, coupled to gas turbine is a technology fully discussed due to its large inducing potential for man made forests.
Some of the several technologies discussed should become extensively commercial before the end of the century.

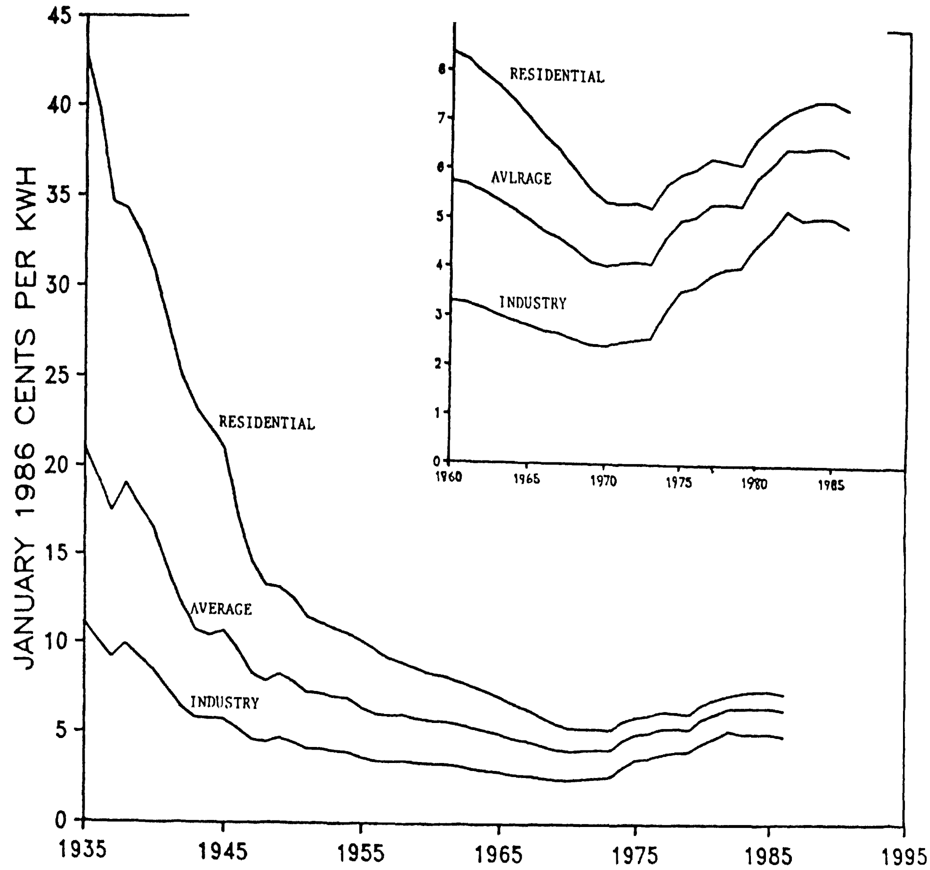


Figure 1 - Long-term and recent (insert) electricity price trends in the United States. The prices shown are the total revenues divided by the total electricity sales[38], expressed in January 1986 cents per kWh

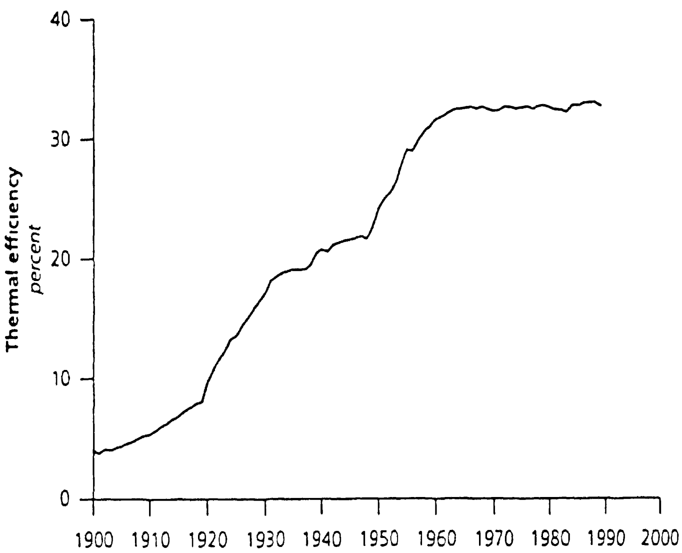


Figure 2 - The historical trend in the average efficiency of electricity generation in central-station power thermal power plants in the United States[40]

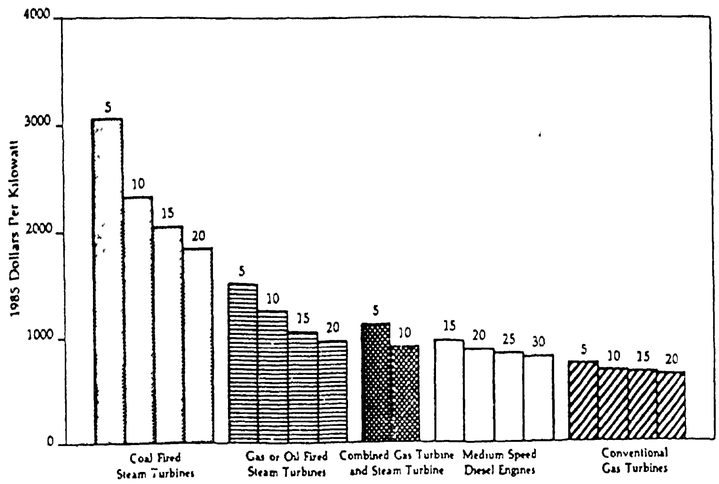


Figure 3 - Unit installed costs for small-scale cogeneration systems. The numbers at the tops of the bars are the installed electrical generating capacity in megawatts(38).

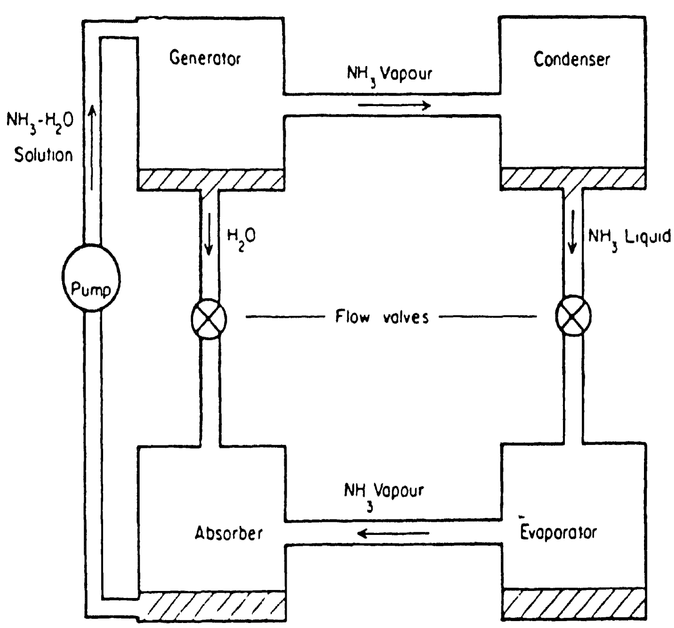


Figure 4 - Absorption refrigeration cycle source - ref. (12)

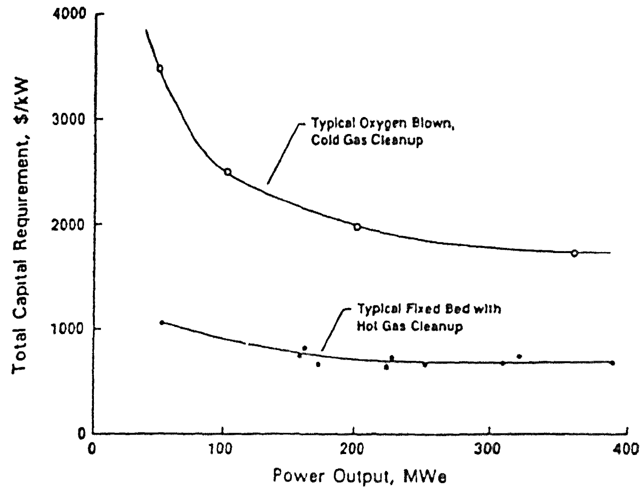


Figure 5 - Cost comparison (in 1988 $) of coal-gasifiers/gas-turbine power plants[37]. The upper curve represents technology like the Cool Water commercial demonstration plant that uses a Texaco entrained-bed gasifier, cold-gas cleanup, and a combined cycle The lower curve represents systems using air-blown fixed-bed gasification with hot gas clean up and either combined cycles or steam-injected gas turbines The points on this curve are calculated costs for specific plants using integral numbers of gasifiers and commercial gas turbines

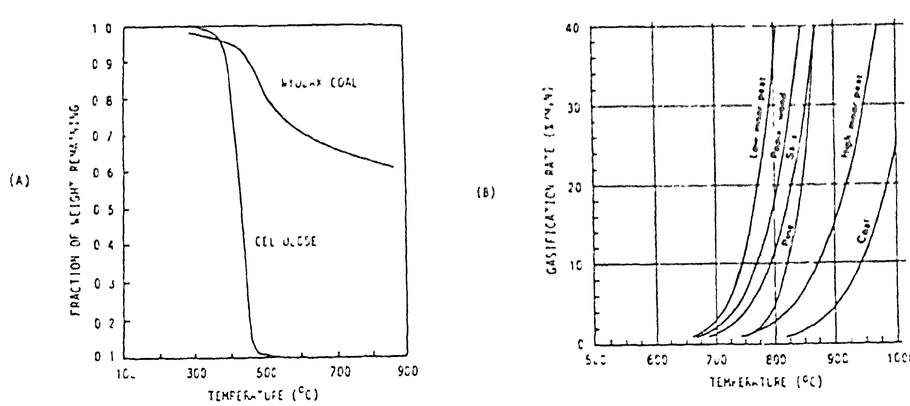


Figure 6 - Comparison of gasification characteristics of biomass and coal[24]. (a) Weight loss as a function of pyrolisis temperature for coal and cellulose (a major component of biomass), (b) Gasification rates in steam of chars from different feedstocks.

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TECHNOLOGY TRANSFER IN THE BANGLADESH CONTEXT

We gratefully acknowledge the generous support provided by Dr. K.I. Omar and Dr. I. Hossain of Bangladesh University of Engineering and Technology, Dhaka, for completing this paper

1. Introduction

Technology, which was once referred to as a "residual" factor for development, is now accepted universally as the "engine" of growth for any economy - developed and developing The four basic components of technology, which contribute equally to the development goals of any economy have been shown as:

(i) **Technoware** Production tools, machines etc , which are the object embodied form of technology.

(ii) **Humanware** Production skills, innovativeness, creativity etc , which constitute the human embodied form the technology

(iii) **Infoware** Production facts recorded as theories, designs, blue-prints etc which constitute the document embodied accumulated knowledge or information

(iv) **Orgaware** Production arrangement linkages which constitute the organizational framework within which technology needs to operate to raise productivity

These components of technology are complementary and interdependent The complementary nature of the components can be explained as follows

- **Technoware** is the core of any transformation It is developed, installed and operated by Humanware
- **Humanware** is the key element of any resource transformation operation and it is in turn guided by Infoware
- **Infoware** is generated and also utilized by Humanware for decision making and operation of Technoware
- **Orgaware** acquires and controls Infoware, Humanware and Technoware to effect any resource transformation operation

It has been observed that the successful developing countries had introduced the right policy instruments which ensured the development and promotion of all the four components of technology Such development led to an effective technology transfer to these countries of the developing world leading to indigenous technological capabilities

2. Technology transfer

Although the term Technology Transfer gives the impression of a donor and a recipient, the situation is quite different in real terms Technology is not

given away free; it has to be paid in one way or other. Technology transfer is the importation of technology based on mutuality of interest

A meaningful and effective technology transfer involves the following steps:

(i) Technology assessment

(ii) Technology acquisition, adoption, adaptation and development

(iii) Technology diffusion

Successful technology transfer occurs only when all the components of technology, as discussed in the previous section, are considered in details in these steps. As discussed in subsequent sections, policy planners, scientists and technologists in Bangladesh have, in most cases, concentrated on the second step As a result, technology transfer activities were not successful

Moreover, the adaptation and development components of the second step did not take place to any noticeable degree All technology that is present in the country has been acquired from abroad and the minimum training requirement for normal operation and routine maintenance has been met

Technical assessment of large projects are being carried out on behalf on Bangladesh by expatriate consultants engaged for the job and paid for by the donor agencies out of the aid allocation

3. Barriers to technology transfer in Bangladesh

3 1 Technology policy inadequacies

Policy studies and initiatives for technology transfer in Bangladesh has remained limited to declarations of intent without the operational mechanism The implementing agencies, in most cases lack the manpower and organizational capability to comprehend the implications of proper technology transfer and are unable to carry out policy directives in this regard In some cases only a small part of the total transfer process has been catered to, resulting in stunted growth

The first attempt towards the formulation of a state policy for Science and Technology was made in 1980 and in 1985, a comprehensive National Science and Technology Policy (NSTP) document was prepared and circulated A section of the NSTP deals with "Establishment of a national capability for development of indigenous technology and attainment of a national capacity for the assessment, selection, acquisition, adoption and adaptation of foreign

technology." In this connection a committee named the Consultative Committee on Transfer of Technology (CCTT) was formed in 1987 for implementation of the National Science and Technology Policy. This committee has suggested some action programs and indicated the institutional arrangements for their implementation. However, as yet nothing tangible has been achieved.

3.2 Human resources and research and development

High literacy rate and skilled manpower are prerequisites for technological advancement. In Bangladesh the literacy rate of 15 years and above is 29.2% only. In addition, the emphasis historically has been towards liberal arts subjects rather than science and technical subjects. As a result, the technical education base is weak.

As already mentioned, bulk of the technology in the country is imported. There has not been any concerted effort for the building up of institutions that could be involved with studies/research on assessment and absorption of imported technology. The various steps necessary in this connection are the identification and evaluation of technological alternatives, regulation of technology importation, engineering design, technology adaptation, experimenting in existing plants etc.

With the exception of some areas in the agriculture sector, most organization lack organized and well-planned research management system. Research efforts are fragmentary, un-coordinated and are generally not related to long term development objectives. Presently R&D activities suffer from shortage of competent manpower. Severe "brain drain" resulting from poor funding and lack of proper service conditions in R&D institutions of the country have in recent times caused a dearth of competent scientists, engineers and other skilled personnel.

Another teething problem of the local R&D institutions is the lack of adequate documentation and information facilities. Even within the country, a proper information network system has not been developed with the sole exception of the agriculture sector.

3.3 The impact of external assistance

In the absence of a comprehensive technology based development policy with cross sectoral consideration as exemplified by the existing situation in Bangladesh, it becomes difficult for funding agencies to identify the technological goals of a developing country.

Up to the present time new and varied technologies of different origins were transplanted in the various sectors of the economy in Bangladesh. Technology transfer was confined to installation of the imported plant with the help of expatriates, training of engineers, technologists and technicians in a similar plant abroad and the supply of a set of operating/instruction manual (often inadequate) and a set of drawings. Such transfer elements amount to a "static" mode of technology transfer and prevents the chances of "dynamic" transfer of technology which is necessary to raise the technological level of the country for undertaking innovative ventures in a competitive world.

As is common in many developing countries "projects" are initiated and implemented which benefit some Transnational Companies (TNC) and their agents. Thus one hears of "Agency Oriented Projects" or "Donor Oriented Projects" - or even projects designed to profit a given supplier of hardware and/or software

Another aspect worth mentioning here are cases in which there are multiple donors of a single project. In these, the spares and raw materials are so varied that local inputs become difficult due to the size of the demand

4. Case study of the cogeneration in the context of technology transfer

4.1 The electric power sector in Bangladesh

The Power Development Board (PDB) is the public sector agency solely responsible for the development, production and management of the power sub-sector in Bangladesh

The installed generation capacity of PDB (June 1990) is 3,179 MW of which 1974 MW is suitable for base load operation and the remaining 805 MW for intermediate and peak load generation (2) The total electricity generated in 1990 was 7732 GWh with the following break-up

Hydro	884 GWh (11.43%)
Natural gas based	6615 GWh (84.26%)
Petroleum liquid fuels	333 GWh (4.31%)

PDB's power plants consist of both new and old plants The older plants (some over 25 years) are prone to frequent breakdowns Of the total generation capacity of 2179 MW, the dependable capability is only about 1479 MW.

compared to a peak demand of roughly 1600 MW. Thus power supply remains unreliable.

Thermal efficiency of generating plants (mostly steam thermal units) is low (approximately 25%) Moreover the technical and non-technical losses of PDB's power distribution amount to a staggering 40% PDB therefore operates at a very low level of efficiency

4.2 Participation of the private sector in the power industry (Electric power)

Before the establishment of the Power Development Board (PDB), private companies operated and managed electric utility services At present the power sector in Bangladesh is totally controlled by PDB with the exception of a few standby generators in some industries The Fourth Five Year Plan (1990-95) however, has laid emphasis on private sector participation on Build Operate and Transfer (BOT) basis for power generation However detailed studies are yet to be carried out for deciding the appropriate strategies for private sector participation. A clearly stated policy to encourage local/foreign private investment is required

It is felt that privately owned and managed power generation units could meet the growing demand for power and be, at the same time more efficient and reliable than PDB

4 3 Cogeneration technology and Bangladesh

In Bangladesh, cogeneration provides the bulk of the electric power for the fertilizer, paper and sugar industries Additionally, some industries such as cement have self generation capability

A technical potential exists for further utilization of cogeneration in Bangladesh in six industry sectors

- Other paper and allied products
- Tea
- Other food
- Jute
- Textiles
- Other manufacturing industries

Based on a recent analysis (3), the greatest potential exists in the jute and textile sectors,two industries with very significant electricity consumption

The economic potential for cogeneration is shown below (in PJ)

Industry	Electricity consumed at present	Electricity which can be displaced under cogeneration
Other paper & allied products	0.14	0.09
Tea	0.50	0.04
Other food	2.02	0.47
Jute	3.54	2.27
Textiles	2.60	1.67
Other manufacturing	2.20	0.61
	11.03	5.15

Thus a net savings of 5.15 PJ could be realized through initiation of a national industries cogeneration program. This represents approximately 12.0% of the fossil fuel consumption for power generation.

The technical potential for cogeneration was determined through examination of the detailed energy consumption patterns by industry. Upon preliminary examination of the economies of various cogeneration systems it was determined that gas engines with waste heat recovery (hot air, steam and/or hot water) and gas turbines with heat recovery steam generators were the most viable.

Further economic analysis on these cogeneration system revealed that the minimum economic size for a base loaded unit is 500 KW electric and for a unit designed to deliver peak demand is 1000 KW electric. The economic potentials for cogeneration was determined as those plants which have power demand greater than those above.

The total investment requirements for a national cogeneration program are estimated to be US $ 76 million (1984). Cogeneration can potentially save significant quantities of energy and also reduce the burden on PDB's overstretched generation capacity.

However, a number of major policy issues need to be resolved before cogeneration will be feasible for general implementation in Bangladesh Cogeneration will require a concerted government effort to effect significant implementation and is at present of medium priority. In the near term, the focus should be on resolving the policy issues; in the medium term (assuming the policy issues are resolved) the focus should be on demonstration projects and initial implementation; in the longer term a full implementation effort should be pursued

For cases of New boiler construction or replacement of old boilers the economic incentives of cogeneration is even greater with poor power reliability, self generation can be both cost effective and also energy efficient. Implementation of industrial cogeneration system would have a major impact on reducing energy use

4 4 Specific examples of cogeneration potential

The cogeneration potential and investment requirement along with profitability analysis of three industries has been recently studied by the Energy Monitoring Unit (EMU) of the Ministry of Energy and Mineral Resources (4) The summary of these studies is presented in Table 1 The industries are Jute (I), Textiles (II) and a combination of jute, textiles and tea (III) All these projects show good internal rate of return (IRR) and small payback period Cogeneration and captive power generation can, therefore, save considerable amount of energy and thus lead to lower carbon emissions

Table 1: Cogeneration potential of three local industries

	I (Jute)	II (Textile)	III (Combined)
Annual power saved (10^6 KWh)	2.24	9.82	8.63
Fuel to engine (GJ)	24321	102435	89977
Steam (kg/hr)	196	1171	1020
Heat recover from exhaust + jacket cooking (GJ)	2061	17356	12968
Annual energy saving (Gas to boiler) (GJ)	2748	21696	17251
Net annual income (1992 '000 $)	72	324	305
Investment (1992 '000 $)	242	1305	1222
IRR (%)	28.9	23.8	21.8
Payback period (years)	3.39	4.03	4.35
Technology			
Generator capacity (MW)	440	900x2	960x2
Boiler capacity (kg/hr)	245	2000	2000

Table 2: Breakdown of investment requirement

	Lakh Taka
A) Engine/alternator sets	275.00
B) Waste heat recovery boilers	40.00
C) Civil and building works	16.00
D) Mechanical installation	5.00
E) Gas installation	5.00
F) Electrical installation	53.00
G) Spares	15.00
H) Engineering design/project management	5.00
I) Import duties and taxes	50.00
J) Monitoring and bank costs	9.58
K) Contingencies	15.00
TOTAL	488.58

(1992 $ = 40 00 Taka)

The breakdown of the investment requirement of one of the projects (Combined, III in Table 1) is shown in Table 2 As is evident the obvious drawback of cogeneration projects is the high initial investment required for the latest state of the art cogeneration technology. Furthermore over 85% of the investment would require foreign currency. Table 1 shows that the technology suggested in all cases is gas fired reciprocating engines and waste heat boilers. At present it is not possible for Bangladesh to develop its own technology for the production of efficient generators Waste heat boilers may be produced locally if effective technology transfer can be achieved. Soft loans must be provided to help local industries in acquiring the state of the art power generation technology. In fact, international financial institutions like the World Bank has agreed to finance cogeneration projects, which is a positive step in the technology transfer process. However, sectors where cogeneration potential is high namely jute and textile, are either incurring losses or are only marginally profitable. The credit worthiness of these industries are not

loans obtained from the World Bank. Therefore, despite the good viability of such projects as indicated in Table 1 in terms of saving both money and energy, little has been achieved towards actual implementation of cogeneration projects.

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OVERVIEW OF TECHNOLOGY DEVELOPMENT OF CO-GENERATION AND ENERGY-SAVING LIGHTING IN CHINA

We gratefully acknowledge the generous support provided by Prof. Wu Zongxin and Prof. Wei Zhihong of Institute of Nuclear Energy Technology, Tsinghua University, Beijing, China, for completing this paper

Overview of Technology Development of Co-generation and Energy-saving Lighting in China

1. China's attitude about technology transfer

Environment and development are two major concerns of the international community. In past, neglect of the environment in the course of industrialization, particularly the irrational exploitation and utilization of natural resources, has caused global environmental pollution and ecological degradation, posing a real threat to the survival and development of mankind It is therefore an urgent and formidable task for all countries around the world to protect the environment and maintain sustainable development.

China considers that solutions to the two issues of environment and development have to call for extensive and effective international cooperation, since environmental protection is a common task of mankind as a whole However, international cooperation will only be a mirage without a guarantee of funds and technology transfer. As mankind shares one earth and environmental problems sometimes transcend national and regional boundaries, a global approach is in the common interest of all countries and regions Historically, environment problems stemmed mainly from the excessive consumption of natural resources and massive discharge of pollutants by developed nations in the course of their industrialization. Even today, their consumption of natural resources and discharge of pollutants, whether in terms of total volume or per-capita share, far exceeds that of developing countries Therefore, they should assume the major responsibility for the deterioration of the global environment On the other hand, they have greater economic strength and more sophisticated technologies for environmental protection, so that it is natural for them undertaking a greater obligation for its solution They should provide developing countries with new and additional funds and transfer technologies of environmental protection, especially those commonly used in energy conversion sectors and end-use service, under concessional conditions to help the latter to improve their environmental and participate in the activities of global environmental protection This is a wise thing for developed countries to do, since it serves both their own interests and those of developing countries

The Chinese government has made environmental protection one of its basic state policies and incorporated it into its national economic and social development strategies. On one hand, China has obtained remarkable results in environmental protection by its own hard work, e.g. over the past decade or more China has, in the course of reform and opening up, maintained steady economic growth while averting a corresponding degradation of the environment, with even some local investments. On the other hand, China is still willing to receive technologies transfer to accelerate its environment improvement.

2. Co-generation

2 1 Current situation

China's generation sets and the contribution of the co-generation in 1990 are shown in the following table

Power generation and co-generation in China

	Capacity (GW)	Percentage (%)
Total Installed capacity	137 89	100
1 Hydro Power	36.05	26
2. Thermal Power of which Cogeneration	101.84 10	74

Total installed capacity of co-generation in the table only includes the units with single capacity over 6 MW, which account for 11 3% of the coal-fired units with the same capacity, while the coal-fired units with single capacity over 6 MW takes up 87% of total coal-fired units.

According to the statistics, at present, the industrial heat consumption of co-generation amounts to 87% The largest installed capacity of the thermal power station in operation is 850 MW The Co-generation and district heating system in China are closely related. Co-generation has remained the major source of the urban district heating. According to the statistics in 1990, there are 89 cities with the district heating system in the northern part of China where heating sources are necessarily required, registering 52% of total cities in the north of China. The district heating area is 0 19 billion m^2, the rate of popularization is 12%

2.2 Energy-Saving

2.2.1 Average fuel consumption in power generation

Condensation unit (≥ 200 MW) 394 gce/kwh

Back-pressure unit 200 gce/kwh

Extraction unit 350 gce/kwh

where gce is grams of coal equivalent.

So, the co-generation power plant consumes less fuel than the coal-fired power plant by 44-194 gce/kwh in electricity generation, that also means that as many as 3-13 million tons of coal have been saved and CO_2 emissions have been reduced by 1.6-6.8 million tons of carbon in 1990

2.2.2 Average energy consumption in heat generation

Thermal power plant · 40 kgce/GJ

Decentralized small boiler · 52-62 kgce/GJ

The above fuel consumption shows that the heating efficiency of the thermal power plant rises to as high as 85% while that of the decentralized small boiler is only 55-65% In 1990, the total heat generation in China is approximately 565 PJ, Co-generation has saved 1 2-2 1 million tons of coal and reduced 0 6-1 1 million tons of CO_2 emission (in carbon content) if the district heating rate is calculated by 12%.

2 3 Development prospect

In some industrially-developed countries, co-generation makes up a high percentage of thermal power generation, for example, the percentage is as high as 40% in former USSR Comparatively speaking, development of co-generation in China is slow and backward But, to realize the objectives of energy-saving and environmental protection as well as to meet the requirements of industrial production and growing demand of people's living, [illegible] is expected to find wide applications in the future.

China's energy sectors has set a preliminary energy-saving target for 2000 that the fuel consumption of electricity supply would drop to 360-370 gce/kwh from 427 gce/kwh in 1990, and stipulated that the newly-built units will consume no more than 330 gce/kwh of fuel for electricity supply and no more than 270-280 gce/kwh of fuel for heat generation. It is estimated that during the period of 1990-2000, total new capacity of 90 GW of thermal power plant are expected to be built in order to realize the objective of

energy-saving. They all should be high efficiency co-generation, and take a large share over the existing level of 10%.

* Coal represents more than 85% in the fuel for the thermal power generation, and about 0.29 billion tons of coal is fired every year, thus producing emissions of CO_2, SO_2, NO_x, smoke and dust, and posing serious threat to the environment with the future development of electrical power industry the coal consumption will increase, so it is a necessary and important requirement that the efficiency of power generation be raised to reduce coal consumption so as to protect the environment.
* Now, there are 240 thousand industrial boilers in China, heat generation is about 90% of the industrial heat demand So the replacement of the decentralized small boilers with the large thermal power plant remains far potential.
* The district heating rate in North China is relatively low (12%), and the hot water supply is practically nil. With the improvement of the people's living standard, the demand will impose a high growing heat load.

2.4 Measures and policies

Now, the proper measures and policies have been adopted to encourage the development of co-generation.

* District heating system is encouraged to be actively diffused in urban areas, which is proposed in "Environmental Protection Law of PRC"
* Co-generation and district heating system should be developed, stressed by "Provisional Regulation for Energy-saving Management".
* High-parameter and large-capacity units, including co-generation ones, should be strongly taken into consideration in making future electricity development plan.
* Operation of some small-capacity, medium and low pressure condensation units in service for too long should be stopped in a planned way. For those units which cannot be scrapped at the moment, reforming and renovation will have to be carried out by ways of transforming them into extraction units or back-pressure units. Some of the concrete measures to be adopted could be listed as follows: first, all the total 20 GW capacity of medium and low pressure units should be phased out firmly, and part of them can be permitted to be shifted to the units for heat supply. Second, for the total 60 GW capacity of high-pressure units including the units of 100 MW, 125

MW, 200 MW, and some old 300 MW, special renovation should also be made, and emphases will be put towards 200 MW units, of which there are still 110 units with fuel consumption as high as 410 gce/kwh, to satisfy the target of fuel consumption 360 gce/kwh.

* Studies on the tri-generation of gas, thermal power and electrical power should be conducted in the near future.
* Management of existing power grids would be enhanced, insulation of pipe network and valves would be improved to prevent leakage of heat energy.
* Power grids should be economically dispatched, e.g regional power plants, coal supply could be shifted from small-sized power ones to large sized ones to enable full operation

If all above policies and measures are implemented, the target of reducing fuel consumption per kwh of electricity supply could be realized And, if the capacity of thermal power stations would total to be 100 GW, about 60 Mtce of energy could be saved resulting in removal of 44 million ton of CO_2, and large amount of NO_x and dust.

2 5 Problems to be solved

2 5 1 To develop high-parameter and large-capacity units, it is quite important and necessary to learn the newest design and manufacturing techniques in the world and have technology transfer from the developed countries gratis or on concessional terms

2 5 2 Transformation of the small-capacity, medium and low pressure units into co-generation units needs an investment cost of 2000 Yuan/kw, an equivalent to the current cost for large unit building. If total capacity of 16 GW is planned to reform, an input of 32 billion Yuan is needed, but the annual investment for technical renovation is even less than 0 5 billion Yuan It should open more channels to collect necessary fund to ease the shortage and lay out appropriate policies for investment, price, tax and foreign trade to ensure this process

· Investment

In the existing investment composition of electricity industry, state's investment and loan, fund raising, funds raised by oneself are the major channels, accounting for 17 4%, 17 0%, 17.1% respectively in recent years. Since the economy reform started in late 1970s, the investment pattern depending mainly on state's investment and loan has been shifted to multi-channel ways In particular, the investment policies of fund raising and funds raised by oneself have encouraged

regions and enterprises, where serious electricity shortage exist, to enjoy investing in power industry, because these policies stipulate clearly that "who invests, who would benefit" which guarantee investors having sufficient power supply and then earning better profits.

* Price

The price of heat supply from cogeneration stations is too low to lead them to earn negative profits, e.g. loss of profits from selling heat was about US$ 0.36/GJ in recent years, losses suffered by power industry hinder expansion of cogeneration. It is necessary to adjust the price rationally through price reform combined with economic reform as a whole to encourage the development of cogeneration.

* Tax

In order to ease the situation of fund shortage, a special item of "Funds for Key Energy and Transport Construction" was imposed since 1983. The funds raised has to be used specially for the development of energy and transport sectors. Furthermore, a survey report on the situation of urban district heating submitted by a group of domestic environmental experts recently suggested that smoke tax for decentralized small boilers in urban areas might be stipulated in order to restrict the development of small-sized boilers, and the money of smoke tax would be taken as the special construction funds for cogeneration development

* Foreign funds

Since economic reform and opening up, policy of absorbing foreign funds for domestic economic development has been actively implemented in China, and more flexible approaches will be adopted for perfecting investment environment, providing more convenient condition and legal guarantee to foreign investors, and finally attracting foreign funds The foreign investment will be guided to the major fields of technical innovation in infrastructure and basic industries as well as enterprises, of capital- and technology-intensive industries In past years, a lot of foreign investment was oriented to the development of cogeneration, foreign funds shared about 13 6% of total each year

2.5.3 The stable heat load is considered to be a very important factor to develop co-generation and bring about the economic and environmental benefits. At present, the industrial production lay-out and urban construction are less unified and co-ordinated, thus resulting in decentralized heat load and unstable demand. Therefore, it is necessary to step up the co-generation management, unify the development plan and standardize the construction.

3. Lighting

3.1 Current situation

With the rapid development of the industrial and agricultural production, urban construction and tourism as well as the improvement of people's housing and public facilities, there has been a substantial increase in electrical power for lighting Since 1985, the annual growth rate has come to 15%. In 1990, the electricity consumption in lighting is about 80 Twh, accounting for 13% of total electricity consumption. It is roughly estimated that some 23 Twh of electricity was consumed for lighting by residential sector and 57 Twh by other sectors. Based on this fact and some assumptions of electricity consumption in the sectors of industry, transport, commerce and service, etc , it is derived that lighting load accounts for approximately 40-45% of total peak load In that case, energy efficiency improvement in lighting is one of the important measures to ease tense power supply by reducing peak load.

In 1990, China's production of electric bulbs was about 2 1 billion, while the incandescent bulb output was 1.85 billion pcs, accounting to 88% of total production The production output of the common fluorescent lamp was approximately 0 2 billion pcs, that of high-pressure mercury lamp, high-pressure sodium lamp and others 200 million pcs totally

3 2 Energy-saving

The power rate of most incandescent lamp is 40-75W As is known, incandescent lamp is notorious for low efficiency and large electricity consumption The fluorescent lamp and compact energy-saving fluorescent (i e trichromatic lamp), which are expected to replace the incandescent lamp, will demonstrate great energy-saving potential

Now, the fluorescent lamp made in China only consume 1/3 - 1/2 of electricity needed for the incandescent lamp under the condition of providing same illumination, but its wide application is still limited owing to some circumstances such as comparatively big volume not to be convenience for use, low colouring index not satisfy special requirement in some sectors, low lifetime which does not reach the normal operating hours and higher price compared with that of incandescent lamp.

The trichromatic lamp is the latest product, the lighting efficiency of which is supposed to be 4-7 times that of the incandescent lamp, 1.2-2 3 times as many

as that of the fluorescent lamp and also has long service, convenient size and high colouring index etc.

If an incandescent lamp with 75W is replaced by a trichromatic lamp with 16W power consumption, assuming the average lighting hours to be 1,800 hr. then we can calculate that every year about 10.5 Twh are expected to be saved. The price of trichromatic lamp is 26 Yuan/pcs around, the service life is 3,000 hr.

The average service life of the incandescent lamp is only 1,000 hr in spite of rather low price (0.7 Yuan/pcs). The analysis and comparison show that the application of trichromatic lamp is both highly energy-saving and benefits.

3.3 Development plan

As stated above, we can see the great energy-saving potential of the trichromatic lamp, which is expected to substitute for the current incandescent lamp.

By the year 2000, if every household would have at least one trichromatic lamp, and some enterprises and administrative organizations would also take action to use more of this kind of lamp for energy-saving, it is estimated that there will be 0.5-0 7 billion pcs of trichromatic lamps replacing the incandescent lamps and about 50-70 Twh will be saved, as many as 20 million tons of coal and 10 million tons of CO_2 reduction (in carbon contents)

3.4 Measures and policies

* Increase in investment to establish and improve the industrial production system for trichromatic lamp so as to expand the production and ensure supply. In order to raise more funds and catch up with the world's advanced level, foreign investment and advanced technologies are encouraged to be imported according to policies concerning foreign investment mentioned in above section 1 5.2. For Chinese industry and enterprises, foreign funds with concessional conditions, e g low loan interests and long payback period, are put in priority. Now, some advanced production lines of energy-saving lamps have been imported by Chinese factories, for instance, more than ten kinds of trichromatic lamps are being manufactured by Beijing Electron Tube Plant using imported production lines The new products can generally save electricity by 80% while compared with incandescent bulbs.
* Pay more attentions to the research work of trichromatic lamp. At present, the poor quality poses a serious handicap to the application of trichromatic lamp. The actual service life is about 1,000 hr, only 1/3 of the nominal

service, so no economic benefits can be brought to the users. To improve the quality, the emphasis may be placed on the import and introduction of the advanced technological process and production line, for example, the service life of the trichromatic lamp made in Phillips Co. may become 8,000-10,000 hr.

* Go in for publicity and education to raise the public awareness of energy-saving and take initiative to push application of the trichromatic lamp.

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TECHNOLOGY TRANSFER IN THE INDIAN CONTEXT

We gratefully acknowledge the generous support provided by Ms. Amrita N. Achanta, Mr. S. Bhattacharya, Mr. G. Chandrasekar and Mr. Akshay Jaitly of Tata Energy Research Institute, 9 Jor Bagh, New Delhi, for completing this paper

1. Introduction

1.1 Technology transfer

The Conventions on Climate Change and Biodiversity adopted in Rio in 1992, both envisage technology transfer for developing countries. The developing countries are expected to meet certain commitments conditional to these transfers being made. This necessitates an assessment of the prevalent conditions in which such transfers would be made. This report commences with a general discussion of the issues involved in technology transfer, followed by a discussion of the barriers hitherto preventing an effective transfer under Indian conditions; and finally a brief description of policy reforms introduced by the government to facilitate technology transfer and foreign direct investment.

Technology transfer can be defined as the process by which technology, knowledge and/or information developed in one organisation, in one area or for one purpose is applied and utilised in another organisation, in another area or for another purpose.

Bell (1990)[1] distinguishes between these categories of transferrable technology and has identified them as three flows :

i Flow A Capital goods, Services and Design Specifications

ii Flow B Skills and Know-How for production

iii.Flow C: Knowledge and Expertise for generating and managing technical change.

Transfer of technology can occur from a supplier to a recipient by various mechanisms both commercial and non-commercial. The principal routes of commercial transfer of technology are .

1. Direct foreign investment in a host country subsidiary or a joint venture
2. Licensing of industrial property rights
3. Technical assistance
4. Sale, importation,installation and servicing of machinery and equipment and other capital goods and
5. Franchising of consumer goods and services

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[1] Bell,M., Continuing Industrialization, Climate Change and International Technology Transfer. A Report prepared in collaboration with the Resource Policy Group,Oslo,Norway. Science Policy Research Unit.University of Sussex. (1990)

The success or effectiveness of transfer of the technology would be dependent on the prevalent conditions within the recipient country, apart from the stage of technological development, characteristics of end users and potential for absorption and diffusion within the recipient country, among other factors. The following discussion pertains to some of the barriers identified by individuals involved in collaboration agreements with Indian industry.

1.2 Barriers to Effective Technology Transfer

Some of the barriers to effective technology transfer which have been perceived by foreign industry with respect to collaboration with Indian industry in the past have been identified as :

a.Import restrictions on technology, b. Limited depth of technology transfer, c. Delays in approval,d. Royalty limit of 5 per cent on value added (with exceptions for highly sophisticated technologies); is considered restrictive by international standards apart from the limitation on the contract duration, e. Firms also disliked the control exercised by the Indian Government. In particular they disliked the obligatory sublicensing requirement of Indian law according to which the Indian party could sublicense the technology on mutually agreed terms. f.Procedures to be followed were considered complicated due to reasons ranging from bureaucratic detours, administrative problems,and varying approval procedures. g. The profitability of the technology transfer may be under question due to the tax burden, the customs duties on imports and the potential of better payments for these tranfers.

A study carried out by Desai in the mid 1980's has been considered a landmark study. Some of the findings of this study which was a critique of the import substituting regime were :

1. The extent of foreign technology as well as foreign direct investment has been negligible as compared to other LDCs as measured by number of technical collaboration agreements.
2. Regarding outflow of payments on account of profits and dividends India was way below most other LDC's.
3. Indian collaborations have tended to be shallow in depth of technology transferred.
4. Restrictions have been in existence on foreign direct investment and technology import in the form of restrictions on royalties, duration,

equity participation and absence of large lumpsum payments. This has reduced outflow of foreign exchange simultaneously decreasing the depth of technology transferred.

5. It was found that technology import did not deter indigenous research effort and importers of technology tended to do more research.
6. Multinational corporations were not the major sources of the technology transferred so far.
7. The highly sheltered import-substitution industrialization regime lead to a lack of competitive pressure to upgrade existing technology.
8. The prevailing industrial policy discouraged the existence of the kind of firm which could effectively negotiate and assimilate technology.
9 The study also focused attention on Government expenditure on industrial R&D. They have been unable to generate the requisite amount of commercially relevant technology and the income generated from the sale of such technology has been negligible

The study also advocated some remedial policy measures such as :

1. Liberalization of restrictions on the import of technology
2 Simplification of procedures
3. Removal of limits on royalties
4. Removal of limit on lumpsum payments
5. Encourage foreign equity participation and therefore modify Foreign Exchange Regulations Act.
6. Encourage R&D through tax concessions, incentives to in-house research and development like investment subsidies and other financial support.
7. Lower trade barriers
8. Delicensing and broadbanding
9. Removal of FERA (Foreign Exchange Regulation Act) and MRTP (Monopolies and Restrictive Trade Practices) controls on large and foreign enterprises
10. Dereservation of products for the small scale sector and industries for the public sector
11. Exposure of public sector to competitive pressures
12. Removal of restrictions on mergers.

The inclusion of these study findings is significant because of its relevance in the present altered environment meant to encourage and/or

facilitate technology transfer. These liberalization measures introduced by the Government have to a great extent removed the irritants hitherto discouraging such transfers.

1.3 Transfer of Technology Regulations

In India transfer of technology regulations, relate to the major policy areas of (i) Technology policy,(ii) Foreign Exchange Regulations (iii) Industrial policy and (iv) Trade policy.

Till recently, entry of foreign capital and technology into India, have been allowed if they met the following conditions:

a) Undertakings either Indian or foreign should conform to the general requirements of the Industrial Policy.

b) Foreign concerns are permitted to earn profits subject to regulations common to all other enterprises functioning within the country.

c) Foreign exchange considerations would determine the freedom to remit profits and repatriate capital.

d) The major interest in ownership and effective control of an undertaking was to be in Indian hands.

Two major policy statements have affected significantly the transfer of technology. One being the Industrial Policy Statement (1980) and secondly the Technology Policy (1983). A new industrial policy statement has been released as recently as July 1991 This is discussed later in the report. The noteworthy features are that import of technology can be considered under certain circumstances

- if technology is not too closely held and is not available on competitive terms
- if technology is required for updating the existing technology to meet higher domestic requirements or to become competitive in the export market
- if the technology is required for production of items with substantial exports backed by buy-back guarantees.

Collaboration agreements are subject to Indian law and are expected to meet certain terms and conditions.

a. The Indian party should be free to sublicense the technical knowhow/product design/engineering design under the agreement to another Indian party on terms to be mutually agreed to by all the parties

concerned including the foreign collaborator and subject to the approval of the Government.

b. The percentage of royalty is dependent on the nature of the technology but should not normally exceed a limit of 5 percent on sales.

c. The collaboration agreement should be for a duration of ten years, including the period for going into production.

d. There should not be any binding clauses in the Indian agreement relating to procurement of capital goods, components, raw materials, pricing policy and so on.

e. Use of foreign brand names is not permitted for internal sales.

f. Under the Foreign Exchange Regulation Act both Government approval and Reserve Bank approval is required prior to entering such collaborative agreements

Renewal of contracts has also been difficult under Indian conditions and was normally done in exceptional cases like:

1 Item of manufacture sophisticated and period of collaboration needs to be extended so that absorption of know-how may occur.

2 When collaboration agreement relates to the manufacture of a number of related items and the delay in manufacture of certain items may necessitate an extension.

3 An extension could be made if it is likely, to affect the export of the manufactured product. Even when such extensions are granted every effort is made to reduce the royalty payable.

1.4 The Technology Policy Statement (1983)

The technology policy lays down the guidelines towards technology acquisition by India. The policy encourages self reliance but does not imply self sufficiency.

Acquisition of technology is governed by some of these principles not all of which are discussed within this report.

a) Import of technology and foreign investment should be on a selective basis where need has been established and the technology does not exist within the country and the time required to develop the technology would delay achievement of development targets.

b) Absorption, adaptation and subsequent improvement of imported technology must form part of a Research and Development commitment.

The technology policy also incorporates encouragement of in-house R&D. The Department of Science and Technology (DST) in collaboration with the Directorate General of Technical Development (DGTD) operates a scheme whereby recognized R&D units of industrial enterprises receive fiscal concessions and other incentives.

According to the technology policy, based on the access of industry to foreign technologies, industries have been categorized as follows:

a. Those in which indigenous technology was adequate hence no foreign investment/licensing to be allowed.

b. Those in which foreign technology is necessary but tightly held hence only licensing to be allowed.

c. Those industries where licensing and direct investment would both be allowed.

1.5 Policy reforms facilitating technology transfer and foreign direct investment

The new industrial policy announced in July 1991 has been instrumental in substantially deregulating the industrial sector and liberalizing foreign investment and technology imports. The reforms would have far reaching consequences for industry by shifting from a regulatory and protected regime to a free market oriented competitive environment.

1.5.1 Industrial policy reforms

Some of the changes in industrial policy are:

(i) De-reservation of industries for the public sector, with the list of reserved industries being reduced from 18 to 8 Those industries which would continue to be reserved are in those areas where security and strategic concerns dominate.

(ii) Abolishing industrial licensing for all projects except in 18 industries where strategic or environmental concerns are paramount or where industries produce goods with exceptionally high import content.

(iii) The MRTP Act has been amended so that the need for prior approval by large companies for capacity expansion or diversification has been eliminated,to enable Indian firms to become large enough to compete effectively in global markets.

(iv) The requirement of phased manufacturing programmes has been discontinued for all new projects. This had been in force for a number of

engineering and electronic industries in an attempt to quicken the pace of indigenisation in manufacturing.

(v) Areas reserved for the public sector have been narrowed down, and greater participation by the private sector was permitted in the core and basic industries. This has been narrowed to 8 such areas as compared to the earlier 17 areas.

(vi) Government clearance for location of projects has been dispensed with except in the cases of 23 cities with a population of more than one million.

(vii) Small scale industries have been given the option of offering upto 24 per cent of their shareholding to large scale and other industrial undertakings thus allowing them greater access to capital and technology

(viii)A national renewal fund has been set up with a corpus of Rs 200 crore to ensure that the costs of technological change and modernization of industry are not borne by the workers.

Likewise industrial policy has been altered to promote inflow of direct foreign investment·

(i) For a specified list of high technology industries and high investment priority industries firms will receive automatic approval to make foreign technology agreements within certain guidelines. This list has been further altered to increase the number of industries which could obtain direct approval.

(ii) Hiring of foreign technicians and testing of indigenous technology abroad earlier required case by case approval This will not be required any longer.

(iii) The limit of foreign equity holdings has been raised from 40 per cent to 51 per cent in a wide range of 34 priority industries. However, foreign exchange outflow on account of dividends on additional equity will be balanced by export earnings over a period of 7 years from the commencement of production. Foreign equity participation has automatic approval and is cleared by the Reserve Bank of India.

Foreign technology agreements are also liberalized for the same industries allowing them to negotiate the terms of technology transfer based on their own commercial judgement and avoiding the need for

government approval for both hiring of foreign technicians and the testing of indigenous technologies abroad.

(iv) The procedures for investment in non priority industries have been streamlined. The Foreign Investment Promotion Board (FIPB) has been established to negotiate with large international firms and to expedite the clearances required. The FIPB also considers individual cases involving foreign equity participation over 51 per cent.

(v) Technology imports for priority industries are automatically approved for royalty payments upto 5 per cent of domestic sales and 8 per cent of export sales or for lumpsum payments of Rs. one crore.

The response to the new industrial policy has been very encouraging. After the announcement of the new industrial policy, although registrations have been discontinued the filing of industrial entrepreneurs memoranda has replaced it. The number of investment approvals given in 1991 has risen to 5538 from 3335 in 1990. The figure for 1991 includes 3095 Industrial Entrepreneurs Memoranda filed under the new policy , which would have earlier required letters of intent or industrial licenses. 3897 investment proposals were cleared between the announcement of the new policy on 24th July 1991 and 31 January 1992. During the same period, 505 foreign technology import agreements were also approved.

Changes brought about in policies toward direct foreign investment have also evoked a strong positive response from foreign companies. In 1991, a total of 244 cases of foreign equity participation with a proposed equity investment of $504 million was approved. In the previous three years, 1988, 1989 and 1990 the total inflow of foreign equity was $95 million, $120 million and 50 million respectively.

1.5.2 Trade policy reforms

Some initiatives have been taken to provide an environment which would reduce the degree of regulation and licensing control on foreign trade. They are :

(i) Permission to import capital goods was given without clearance from the indigenous availability angle provided this import was fully covered by foreign equity or was upto 25 per cent of the plant and machinery, subject to a maximum of Rs 2 crore.

(ii) Export and trading houses and Star Trading houses are permitted a larger range of imports. 51 per cent foreign equity is also now allowed in trading houses.

1.5.3 Investment in R&D (1990-91)

It is important to assess expenditure on R&D in the light of the measures announced by the government to facilitate technology transfer. A recent estimate of India's annual expenditure on Research and Development in science and technology shows a substantial decline in 1991. The nation's research and development investment in 1990-91 was 4,186.43 crore (0.89 percent of the GNP) as opposed to the 1988-89 figure which was (0.96 percent of the GNP) 4,003 crore.

Although the Government Research and Development investment has decreased (this is significant considering that it is the largest investor in Research and Development), there has been no significant increase from industry.

The share of the industrial sector in the national research and development budget was 23 percent amounting to Rs. 970.29 crores in both the private and public sector. This is of significance given the government's policies of encouraging technology transfer.

1.5.4 Patent protection and technology transfer

The nature and extent of intellectual property right protection extended to technologies within a country, is important from the viewpont that some developed countries believe that a strengthened IPR regime in India, would encourage more technology transfer. In India, the legislation for protection of technology exists in the form of the Patent Act 1970. This attempts to strike a reasonable balance between adequate and effective protection of patents on one hand and the developmental, technological and public interest needs on the other It considers the specific needs and conditions of the country ensuring that protection neither affects public interest , needs of critical sectors of the economy nor hinders the build-up of indigenous technological capacity. It is argued that such a regime would favour the diffusion of technology.

Patent Law and Technology Transfer

A patent is thus a statutory grant by the government (or regulating authority) to inventors and other persons deriving rights from the inventors, for a limited duration, that confers on them the right to exclude others from

manufacturing and selling the patented article or using or imitating the patented process or vending the resultant product.

The standard justification for any class of intellectual property rights, including patents, is that they provide incentives for creative work. Further, these rights are to be granted in a manner that maximizes the difference between the value of the resulting intellectual property and the social cost of its creation, including administration and transactions costs.

There are three issues involved here. First, IPRs regimes are premised on the belief that prospective financial returns drive private creators of intellectual property. In other words, that such private creators will have sufficient incentives only if they have the ability to capture at least some of the value that users place on such property. Second, there is the issue of whether innovative activity takes place at least social cost. This may depend on the extent to which creators borrow ideas or concepts from earlier work. Third is the issue whether the IPRs regime maintains a proper balance between creating and disseminating intellectual property. We now examine how the specific IPR of a patent right (as distinct from copyrights or trademarks) find expression in the Indian legal system.

1.6 Indian patent law

The primary law governing patents in India is the Indian Patents Act 1970, which was based on recommendations of the Tek Chand\Iyengar Commission on the subject. The Act was passed by a special sitting of Parliament in 1970, and came into force on April 20, 1970

Section 83 of the Act enunciates the general principles governing the grant of a patent right and also the broad philosophy behind the Act. First, patents should be granted to encourage invention and to secure that the inventions are worked in India on a commercial scale and to the practical extent possible. Second, they should not merely enable patentees to enjoy a monopoly for the importation of the patented article.

The main features of the Act are as follows:

1. Patentable inventions are usually granted product patents. Process patents are granted for substances used as food or as medicine or drugs and substances produced through chemical processes.
2. Under Section 3, non-patentatable items include inventions relating to atomic energy; methods of agriculture or horticulture, processes for

medicinal, surgical etc treatment of human beings or processes for similar treatment of animals or plants to free them of disease or increase to their economic value.

3. As specified by Section 53, the normal term of all patents is 14 years, except for food, medicine, drugs and substances produced by chemical processes, for which the period of the patent is 7 years from the date of application or 5 years from the date of sealing, whichever is earlier.
4. The patent confers on the patentees the exclusive right to use, exercise, sell or distribute the patented article or substances in India.
5. There is no statutory distinction between Indian nationals and foreign nationals regarding patent rights. However, since India is not party to the Paris Convention, it usually grants national treatment subject to reciprocity.
6 A system of compulsory licensing, under Section 84, ensures the working of the patent after 3 years from the date of sealing. If any reasonable requirements of public interest are not satisfied, any interested party can be licensed on application. The meaning of 'public interest' includes issues around the potential availability and price of the item covered by the patent.
7. If reasonable requirements of public interest are not served, the government may, under Section 87, apply the principle of endorsement of licenses of right for any patent. Process patents for food, medicines, drugs and chemical substances are automatically deemed to be endorsed by licenses of right after 3 years from the date of sealing
8. A patent may be revoked by the central government if its application is found to be mischievous to the state or generally prejudicial to the public. Patents can be revoked for other reasons as specified by the Act

The Act attempts to strike a reasonable balance between the adequate and effective protection of patents on the one hand and objectives of development, technological advancement and public interest on the other. It attempts to consider the specific needs and conditions of the country, ensuring that protection does not negatively affect the public interest and the needs of critical sectors not hinders the buildup of indigenous technological capacity.

There are thus important departures in the Indian statute from typical patent laws in OECD countries, relating largely to the duration of patents and

the patentability of certain products and processes i.e. a normative view of what kinds of inventions may be patented.

1.7 The Dunkel draft text

The Final Act on the Uruguay Round negotiations of the General Agreement on Tariffs and Trade (GATT), also known as the Dunkel Draft Text after Mr. Arthur Dunkel, the Director General of GATT, envisages far reaching changes in the current regime of IPRs, especially that of patents. If implemented, these proposals will have profound impacts on the current Indian system of patents. A look at the proposals is therefore germane to an examination of Indian legislation on patents.

TRIPS (Trade Related Intellectual Property Rights)

The Dunkel Draft Text introduces product patents for all inventions, including food, medicine and chemicals. It extends the protection of IPRs to plant varieties in the form of breeders rights. Further, it provides for the protection of patents for 20 years, regardless of the place of invention and whether products are imported or produced locally. The Draft provides for extremely strict limits on compulsory licensing of patented products by governments, a device commonly used by governments in rich and poor countries for items such as pharmaceuticals. It also extends exclusive marketing rights for five years after the grant of marketing approval in the interim period when product patent applications are under consideration. The TRIPS Agreement envisages an uniform intellectual property regime. Once a developing country like India is a signatory it no longer has the right to either frame or pursue its own IPR regime in line with its developmental goals

TRIMS (Trade Related Investment Measures)

The DDT seeks the removal of all TRIMS within a period of five years. The proposals not only seeks to extend national treatment to foreign investors but also aims to deny the impositions of performance obligations imposed on foreign investors in respect of the use of local raw materials, components and equipment, exports, the earning of foreign exchange, technology transfer requirements etc.

Agriculture

No special treatment for developing countries is provided in the case of price support to farmers. The proposals require a reduction of support to farmers by a minimum of 13.3% by 2003, in all cases where the domestic support is more

than 10% of the value of production. Price support is to be calculated by comparing the fixed external price and the administered price in the country, in the base period of 1986 to 1988. The ability of the government to provide subsidies for agricultural inputs is severely curtailed by the Draft. It allows exemption from reduction for agricultural inputs only in the case for low income or resource poor producers, something that may have serious implications for the diffusion of new technologies. These reductions of subsidies would apply not only to chemical fertilizers but also to bio-fertilizers and new varieties of seeds. The Draft also removes the right of governments to intervene in the market by stipulating that food purchases by the government shall be made at current market prices. This is applicable to purchase made even to maintain stocks for food security reasons or to support public distribution.

Institutional Matters

A council on trade related aspects of intellectual property rights (TRIPS) would supervise the operation of the accord, sitting alongside GATT and the envisaged General Agreement on Services under the umbrella of the proposed Multilateral Trade Organization (MTO). The new agreement in regard to trade in services (GATS), attempts to bring within the ambit of the MTO all services such as banking, insurance, shipping etc. The Dunkel Draft provides for a system of cross retaliation between countries under the disputes settlement mechanism. This allows a country claiming violation of its patent rights by another country to discriminate against the other in the matter of commodity trade. Further, the Dunkel Draft envisages no special or differential treatment for developing countries.

All these rules would have to be implemented in national legislation by the 102 members of GATT, observing the basic free trade precepts of national treatment and non-discrimination between trading partners.

1.8 Effect of the Dunkel proposals on Indian patent law

As can be seen from the above examination of the Dunkel proposals, a number of these will have a profound impact on current Indian legislation relating to patents [2] We briefly examine some of the conflicts between the two

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2 The adoption of a new patents regime will also have significant impacts on prices of commodities and industrial and economic policy in the country, but these are not being considered here.

First, the distinction in the Indian patents regime between product and process patents will have to be removed, since the Dunkel proposals provide only for product patents. Second, the differential terms of patents permitted in India, which varies between 5 and 14 years, will have to be removed and will have to conform to the uniform standard of 20 year operation. Extension of this period could be done further by using process patents. Third, the granting of national treatment to foreign nationals seeking patents become compulsory, in contrast with the current regime, where such decisions are discretionary. In the case of the violation of a patent law, the burden of proof will shift from the holder of the patent to the defendant, in contravention with Indian legal principles, where, thus far, this burden has rested on the holder of the patent.

One of the obligations of the patentee was that the patent was 'workable'; so as to encourage the working of that particular invention within the country. According to the Indian Patents Act (1970) a) patents are granted to encourage inventions and to secure that the inventions are worked in India on a commercial scale and to the fullest extent that is reasonably practicable without undue delay and b) They are not granted merely to enable patentees to enjoy a monopoly for the importation of the patented article. In comparison, import of a patented product would be treated as equivalent to the working of the patent, according to the Dunkel Draft.

Indian patent law not only confers rights of monopoly to the patentee but it also ensures public interest by introducing an element of compulsory licensing or license of right clauses. These obligations on the patentee holder are to ensure the interests of the public are met; these obligations are to be removed according to the DDT Text.

The DDT on TRIPS also completely rejects 'Special and Differential Treatment' presently accorded to developing countries. Although there is provision that the concerns of developing countries vis a vis meeting public policy objectives will not be neglected, there is only a 5/10 year transitional period which is given to these countries so that the domestic laws may be harmonized.

Being a signatory to the DDT TRIPS Text would necessarily mean that India has to automatically accept the Paris WIPO Convention to which it is not a party.

In the following sections the case of cogeneration and lighting technologies will be discussed in the context of technology transfers to India.

2. Case study of the cogeneration industry in the context of technology transfer

2.1 Introduction

Electric power is recognised as one of the key inputs for the development of any modern economy. In India, although there has been a phenomenal growth in the installed generation capacity, a chronic and sizeable gap still exists between demand and supply of electric power. Studies carried out by Central Electricity Authority have indicated that the power shortage was of the order of 13% during the period 1980-85 and would be around 10% from 1985-95. The uncertainty and cost associated with the supply of electric power coupled with the fact that the environmental regulations are becoming more stringent, it is anticipated that the economics of conventional power generation will be adversely affected in future. One of the ways of increasing the efficiency of energy conversion and usage lies in the concept of cogeneration, which means simultaneous conversion of fuel into heat and power. In the following sections, the concept of cogeneration is discussed in brief covering different cogeneration technologies, the scope for cogeneration in India and the barriers to the implementation of the cogeneration programmes.

2.1.1 Concept of cogeneration

The term cogeneration is not strictly an engineering or a scientific term. Cogeneration simply means the sequential use of energy from the same fuel source. In other words, both work and heat producing ability of a given fuel is fully exploited, thereby minimising instances of 'lost work'. Any system that supplies both the steam and elecricity needs of a customer, therefore, qualifies as cogeneration. The technology has merit, as it is more efficient to produce steam and electricity simultaneously rather than produce them separately. Cogeneration is not a new concept. In the US it was very popular in the 1950's when it supplied over 50% of the USA's power needs. With the installation of large power plants, the interest in self generated electricity gradually waned because of economic reasons. Cogeneration, however, made a quick comeback in the US in 1980's. The factors that helped this was the

PURPA policy act that required utilities to accept and pay for self generated electricity at an appropriate 'avoided cost' and the enforcement of stringent environmental emissions. It is estimated that the expected USA cogeneration market (in industries) by the year 2000, will be around 39348 MW (Gainey).

2.1.2 Advantages of cogeneration

The various advantages of cogeneration system are outlined below:

- In a cogeneration plant, a good portion of the exhaust heat which is otherwise wasted in the condensing circuit of a conventional thermal power plant, is utilised in different processes, thereby utilising 70-90% of the thermal energy input.
- Cogenerated electricity, depending on the system, is produced with only 40-70% of the fuel normally required in a power plant.
- It leads to lesser environmental degradation because of efficient fuel use.
- Cogeneration serves as a reliable source of power for the customer.
- It leads to reduction in transmission and distribution losses as the energy is produced in-house.

2.1.3 Cogeneration technologies

Cogeneration systems fall into two distinct categories . topping systems and bottoming systems. In the topping system, the primary fuel is used to produce electricity and the thermal energy exhausted is used for process heating. In the bottoming cycle system, the primary fuel is used to produce high temperature thermal energy needed for furnaces/kilns etc. The hot exhaust stream is subsequently used to produce electrical energy through waste heat boiler and turbine-generator system.

Based on the prime mover used, the **topping systems** are classified as·

- Steam turbine topping system
- Gas turbine topping system
- Combined gas/steam turbine topping system
- Diesel engine topping system
- Fuel cell topping system
- Stirling engine topping system

The **bottoming systems** are based on Rankine cycles and use either steam or organic working fluids. Accordingly, the bottoming systems are classfied as

- Steam Rankine bottoming sytem
- Organic Rankine bottoming system

Topping systems are more widely used in industries. Bottoming systems are used mainly in industries where high temperature waste heat are available and are characterised by higher capital costs than topping systems.

2.2 Potential for cogeneration in India

All process industries such as fertilisers, paper and pulp, sugar, food processing, textiles, petrochemicals, refineries etc. need both steam and electric power and represent ideal cases for the installation of cogeneration plant. An independent study was conducted in 1986 by a team of consultants from Gujarat and Maharashtra (CEI). The study revealed the following potential for these two states alone with respect to cogeneration application for medium and small scale industries

Systems	Cogeneration potential (MW)	Financial cost of generation (Paise/kWh)
Industrial topping systems	2150	up to 130
Industrial bottoming systems	50	70-120
Commercial systems - packaged Cogeneration unit (studies confined to Bombay City only)	50	<160

Note:Systems with electricity generation cost under 130 paise per kWh are considered financially attractive.

Although a similar study on a national level has not been carried out so far, it would be reasonable to asume that a potential of 10,000 MW of cogeneration power exists in India in industrial and commercial systems.

Some independent sample surveys were also carried out in some specific sectors. The results of the survey with regard to paper and pulp industry, sugar industry and textile industry are summarised below.

Paper & Pulp Industry

53 mills were covered under the survey. It was estmated that by generating process steam at a higher pressure (with the help of high pressure boilers), it would be possible to generate 600 MW of extra electric power with the same quantity of fuel presently being consumed at a high load factor and negligible transmission losses.

Sugar industry

A sample survey of a small number of sugar mills revealed the scope or cogeneration by going for higher steam pressure and temperature. It was estimated that the additional power these sugar industries could generate for 150 days a year, would vary from 2 MW to about 3.5 MW depending upon the crushing capacity. The total power which could be generated from about 225 modern sugar factories is estimated to be about 1750 MW without consuming any more bagasse than what is presently being burnt.

Textile industry

Textile mills utilise 60% of their normal steam requirement at a pressure below 60 p.s.i.g, while in most cases, the boilers installed in these mills are capable of generating steam at 150 p.s.i.g. or more. The low pressure steam is generally obtained through pressure reducing stations which leads to wastage of available energy. In a textile mill which is producing around 1,00,000 meters of cloth per day, a small back pressure turbine can produce nearby 160 kWh of electricity and simultaneously low pressure steam for the process heating purposes in the mill.

In spite of its vast potential, the cogeneration concept is not exploited fully in India. The reasons for this are many, but some important technical, economic and institutional barriers are mentioned below:

- In developing countries like India, the required hardware may not be readily available in adequate numbers and may have to be imported for speedy implementation. Capabilities for manufacturing cogeneration systems based on coal/oil based steam generator and turbine generator do, however, exist in our country. Capability of indegenous manufacture of gas turbine based generators and diesel generators is, however, very limited.
- Lack of skilled manpower required for the operation of cogeneration system and technical problems like tube failures in the high pressure system make the industry wary of tapping cogeneration potential.
- The design of cogeneration systems are site specific. Hence most systems are custom made depending upon the specific requirements. Sometimes due to lack of technical know-how, industries by themselves are not capable of undertaking the design of cogeneration systems.
- Cogeneration schemes are capital intensive and as such, financial support in terms of soft credit, concessional customs duty etc. may encourage industries to take up cogeneration programme The high initial cost, however, should not act as a deterrant A preliminary assessment indicates that the cogeneration investments arehighly profitable with payback periods ranging from less than one year to five years for different industry sectors (3)

  Electricity boards should allow paralleling of cogeneration systems with the grid supply and in order to improve the economics of cogeneration system should buy the surplus energy generated by the plant. The reason being that sometimes the industry requirements may not be fully met by the cogeneration system and hence there is a need to

interface this system with power utility so that the system can buy power from the grid. In the event of excess power being generated, the system can sell powerto the grid or to another industry by wheeling the power through the power utility transmission network. The main problem foreseen in this type of arrangement is in the fixing of tariffs for the interchange of power. The concept of 'avoided cost' as in PURPA act can be followed in this regard. Under this scheme, the utility buy back the excess electricity generated at a cost which the utility would have had to invest in order to produce that power at that time.

- Some users feel that the size of cogeneration schemes being small, there is little incentive to operate in parallel with the grid, and the electricity boards are also not keen or willing to reciprocate with power supply during breakdown of cogeneration units.
- Clients like paper mills are wary of switching over to coal in view of problems of coal dust affecting their product quality. The other fuel options are gas and fuel oil. In the event of direct gas not being available, any solution with fuel oil may not be commercially viable.

2.3 Conclusions

The design of cogeneration systems permit cascading of energy from the highest possible temperatures to lower temperatures, thereby generating work and providing thermal energy for the process. The concept of cogeneration is not new and is practised very extensively in Europe and North America for a long time In India, although a systematic study to assess the cogeneration potential on a national basis has not been made so far, but the scope appears to be tremendous. It may be worthwhile to identify certain specific sectors and carry out detailed techno-economic feasibility of the cogeneration scheme. Although it seems that technical barriers can be overcome, but large scale implementation of cogeneration programme, will largely depend on removing institutional and economic barriers as outlined in the report.

3. Specific technology study on energy efficient lighting technologies in India

3.1 Introduction

In India, four different types of lighting systems are widely used - incandescent, fluorescent, mercury vapour, and sodium vapour Table 1 shows that over 80 percent of incandescent use is in the domestic sector, over 90 percent of fluorescent energy use is in the industrial, commercial and miscellaneous sectors, and over 60 percent of mercury and sodium vapour lamp energy use is in the industrial sector. However Indian electric utilities do not have precise data on the contribution of electric lighting to the total utility load. This is because electric lighting is required by domestic, commercial and industrial consumers and no separate metering arrangements exist to determine the contribution of electric lighting to the total load for each sector. Hence all available data is based on sample surveys or on macro level

assumptions on share of lighting in the total connected load or on the utilization pattern of lighting equipment.

Table 1:Lighting electricity use by sector & lamp type (Twh)

Lighting system type				
Sector	Incand.	Fluor.	Mercury	Sodium
Domestic	7.4	0.3	0.0	0.0
Comm.& mis	1.2	6.2	0.1	0.1
Industrial	0.3	6.5	1.2	0.8
Public lgt	0.2	0.9	0.2	0.3
Total	9.1	13.9	1.5	1.2

Gadgil and Jannuzzi estimated the share of electric lighting as 17.4 per cent of India's annual energy consumption. If the electric lighting requirements during system peak, which occurs between 1800-2100 hours, were to be fully met, it would constitute 30-35 per cent of this unrestricted demand.

Data based on a sample survey of 400 consumers in Delhi indicated that the percentage share of lighting in the total connected load was about 15 -20 per cent. In villages the share of energy use in lighting is much higher at 70 per cent due the restricted appliance ownership pattern of the rural consumers. The break up of this connected load in four electrical districts where the survey was conducted are shown in Table 2

Table 2: Percentage share of lighting in the connected load

District	Fluorescents %	Incandescents %
1.	40	60
2.	26	74
3.	24	76
4.	23	77

Similarly a survey of domestic and commercial consumers conducted in South Bombay showed that domestic lighting contributes 18.7 per cent of the system load during the peak time.

The share of lighting and its contribution to peak electricity demand are expected to increase in future. The major reasons for this are:

(i) The population in the rural areas account for about 75 per cent of the total population of India. Even though there are large scale rural electrification programmes, only about 25 percent of the households in electrified areas actually have electricity in their homes.

(ii) The shares of both domestic and commercial electricity consumption have been steadily increasing. Table 3 shows the details. Lighting and space conditioning loads are primarily responsible for this increase. This trend is likely to continue.

Savings potential

As mentioned earlier the increasing migration of population from rural to urban areas, shift from non-commercial to commercial sources of fuel and large scale rural electrification programmes have increased the share of domestic and commercial sectors in the total energy consumption from 17.3 in 1980-81 to 21.64 at the end of 1988-89. What makes energy efficiency in lighting more important is a very high peak coincidence rate, arising due the fact that majority of the lighting equipment in the domestic & commercial sector are being used in the evening hours which is peak period for most systems in our country

There several options for improving the energy efficiency of lighting systems in the domestic sector These are:

1) Replacement of incandescent lamps by conventional tubular fluorescent lamps fixtures
2) Replace incandescent lamps with compact fluorescent lamps.
3) Use TLD fluorescent lamps in place of conventional fluorescent lamps.
4) Use of electronic ballasts for fluorescent lamp lighting systems.

There are many more technological options for improvement of end use efficiency in lighting but we feel that only these would make a considerable impact on the Indian power scene. The current stock of lamps in India is about 225 million of which incadescents acount for about 152 million and fluorescents for 68.5 million The details of the number of light points are given in Table 3.

Table 3: Number of light points, million

	Incand.	Fluor.	Mercury	Sodium	Total
Domestic	140.69	5.63	0.00	0.00	146.32
Commer.	6.28	25.13	0.00	0.00	31.41
Industr.	1.18	19.57	1.89	0.94	23.58
Pub.Lgt	2.20	7.11	0.44	0.51	10.26
Other	1.58	11.06	0.55	0.24	13.43
Total	151.93	68.50	2.88	1.69	225.00

Incandescent lamps convert about 4% per cent of the input electricity into light, while the conversion in fluorescents is about 10%. Compact fluorescent cost about Rs.250 each and are available in various sizes and ratings. The life of these lamps is about 8000 hours on an average. Fluorescent lamps of 40 W are most commonly used in India. The average life of these lamps is about 4000 hours. Incandescents last about a year and have an average rating of about 60 W. The main difference is in the cost of installation which are Rs 15 and Rs 130 respectively.

3.2 Indian lighting industry

While the technology for manufacturing fluorescent lamps and electronic ballasts is available in India, the compact fluorscents have not yet entered the Indian markets.

An attempt was made by the Department of Scientific and Industrial Research (DSIR) to evaluate the state of the Indian lighting industry. The report recommended introduction of new energy saving lamps, support & upgradation of small scale units, R & D thurst in basic lamp making processes and establishment of an all India Institute of lighting technology Lighting Industry in India.

The conclusions which emerged from the report are summarized below.

a) The industry has been generally slow in product innovation and machinery renewal.

b) The industry is charecterised by poor productivity, high production cost & low material efficiencies It was felt that the quality of materials and components need to be improved.

c) To improve the lighting industry to world standards free technology and reduced import duty on sophisticated equipment for energy saving lamps as well as components would be helpful.

GLS lamps are manufactured in India are in the range of 15 W to 2000 W, used for general purpose lighting in the domestic and commercial units The luminous efficacy of the lamps range from 8 to 15 lm/W. About 75 per cent of the general lighting service or GLS lamps which are for use in domestic (and some commercial) applications are manufactured by 20 large and medium scale companies in India. Production levels have risen from 12 million pcs in 1940 to about 260 million pieces in 1990. There is no discernible trend in production of GLS lamps.

Fluorescent lamps in India produce between 60-80 lm/W and can be designed either for high efficacy or good colour rendering. Fluorescent lamps

pieces annually. The low capacity utilisation of these units is an indication that the lamp production can be increased considerably without further investments in capacity.

3.2.1 Technology acquisition

As regards the compact fluorescent lamp, the technology for manufacturing is not available in India at present.However, several companies are planning to manufacture these lamps in India in the near future. In the mean time, CFLs are being imported into India in small quantities. The technology for these projects would be made available by PHILIPS (Netherlands), OSRAM (Germany), GE (U.S.A) and PHOENIX ELECTRIC (Japan) to their counterparts in India, PHILIPS India, Surya Roshni, Apar Ltd., and Halonix Ltd. respectively. The acquisition of technology has not been a problem, as all these Indian companies had tieups already existing for manufacture of other type of lamps. Discussions with the manufacturers revealed that there was no inhibition on part of the collaborators to provide the latest technology. The manufacturers however felt that the prevailing import duties on equipment should be reduced from the present figure of 110 percent plus CVT(countervailed tax) as an incentive to manufacture compact fluorescent lamps in India.

3.2.2 Technology absorption

Indian consumers seek to minimize the initial cost of a piece of equipment and do not pay much attention to operating costs. There is general consumer reluctance to invest in efficiency. CFL's, being aproximately 10 times more expensive than the conventional sources of light, do not find consumer acceptance. At present, consumers in India are looking at CFL's more as a fancy lighting system rather than a energy efficient source of lighting. Under these conditions it is unnatural for companies to plan for manufacture CFL's for the domestic market only. Discussions with manufactures also indicated that at present it would not be economical to manufacture these lamps in India as the market is quite small. Some of the manufacturers are planning to go in for CFL manufacturing plants in export processing zones which offer reduced customs duties for import of equipment in turn for a firm export commitment. These export oriented manufacturing zones also allow the units to sell asmall percentage of their production in the domestic market At present there is a shortage of CFLs in the international market The Indian manufactures could possibly take advatage of this global situation As mentioned earlier, the manufacturers are trying to first build the market by slowly exposing the consumers to this technology by making available small quantities of CFL's imported from their respective collaborators. They feel that innovative financing schemes are required to increase the demand of these lamps in India. The manufacturers are looking at large campuses belonging to autonomous bodies and public sector companies so as to ensure smooth operation of financing schemes. For achieving this end some of the manufacturers are also planning to tie up with leasing firms. Another measure for increased penetration of CFL's in India would be introduction of such schemes by government funding agencies/financial institutions. The Industrial development bank of India (IDBI) has a implemented such a scheme for industrial consumers. Under this scheme industries get 90 per cent of the total amount of required for changing over from high pressure mercury vapour lamps (HPMV) to high pressure sodium vapour lamps (HPSV). The remaining amount is recovered through part payments over a period of five years.

3.2.3 Technology adaptation

There are several labs in India which test lighting equipment and issue certificates of performance levels. However, at present the Bureau of Indian standards does not have any standards of performance for the compact fluorescent lamps. The basic infrastructure for lamp testing does exist in all the labs belonging to the BIS. Apart from labs of the BIS,the National test houses and some of the regional test centres, also have facilities for testing lamps. At a later stage, these facilities could be upgraded to test compact fluorescent lamps. Among research institutes in India, The Central Power Research Institute (CPRI), at Bangalore has carried out fundamental research on CFL's. This institute has also brought out a report on the performance of CFLs. It covers technical aspects like life of these lamps under Indian conditions, luminous efficacy compared to other sources of lighting, etc.

The National physical laboratory, a government funded research lab also has infrastructural capabilities for testing and research purposes. However, the time taken by these labs for providing test results is quite long due to a large number of interested clients. There is an urgent need to increase the number of test centres in view of the ever increasing demand.

4. Conclusion

It is obvious from the foregoing discussion that technologies for both cogeneration and efficient lighting are easily available to the Indian manufacturers. The only lacuna seems to be lack of institutional facilities to promote them, as also a low level of consumer awareness.

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TECHNOLOGY TRANSFER OF CO-GENERATION SYSTEMS IN INDONESIA

We gratefully acknowledge the generous support provided by Dr. Saswinadi Sasmojo, Dr. Moekti H Soejachmocn and Dr. Ucok Siagian of Center for Research on Energy, Institute of Technology, Bandung, Indonesia, for completing this paper

1. Introduction

An investigation on the status and development of the functioning of co-generation systems in Indonesia, and an evaluation of the opportunities for its wider application possibilities has been carried out.

The study is mainly concerned with the question of: (a) what opportunities are open for the wider functioning of co-generation systems in Indonesia, (b) what is and would be the role of international transfer of technology of Indonesia in influencing the development of wider application of co-generation system, and (c) what would be necessary to promote a better environment for such transfer process to occur.

Prior to answering those questions, a set of relevant background information will be provided, namely the general economic development of the country, the developments in the energy sector, and major issues pertinent to technology transfer processes in Indonesia

Having analysed the technology transfer issues pertinent to the wider functioning of co-generation systems, a scheme for investment is proposed, whereby technology transfer of co-generation systems in selected applications is envisaged to take place beneficially in terms of improving energy efficiency of those selected area of applications Such efficiency improvement will, in turn, suppress the rate of generation of spent resources from energy use, thereby will reduce emissions of environmentally undesired substances One can also expect that the improved energy efficiency will result in better economic performance

Excluding this introductory section, the report is organized into four sections First, an overview of the Indonesian energy setting will be given. Following that, some of the major issues in technology transfer will be discussed This is followed by an analysis of technology transfer of co-generation systems can be [illegible] promoted

2. Overview of the Indonesian energy setting

2.1 General overview

Oil is dominating the supply and consumption of energy in Indonesia Other major commercial energy, in decreasing order of relative shares of production and consumption, are natural gas, hydropower coal and geothermal Biomass, as traditional form of energy, has a very high share in the total energy supply, currently estimated at 40% Its main consumption is in the rural and urban peripheral residential sector

The domestic use of coal has been accelerating for the past five years, and the level of production is also increasing rapidly However, the share of

coal in domestic energy supply is still very low and mainly used in power generation and the cement industry.

Electricity generation as energy supply has also developed at a rapid rate, catering for the growing needs of the industry, urban households, and rural electrification program. Considerable opportunity for improvement with respect to losses can be found in the power sector; the margin between electricity production by PLN and the electricity consumption is about 25-35% of the generated electricity.

An overview of energy resources in Indonesia is given in Table 2.1.

Table 2.1. Energy Resources of Indonesia

Oil	6.78×10^9 tons
Natural gas	6.04×10^{12} m^3
Coal	28.3×10^9 tons
Hydro	75,000 MW
Geothermal	16,000 MW
Uranium Peat Wind	indicated 200×10^9 tons prospective
Biomass	1.085×10^8 km^2 forest area and agro & silvicultural waste
Tidal, wave and ocean-thermal	identified

Concerning the energy consumption, at least at the last decade, the industrial sector has always the highest share of commercial energy consumption followed by the transportation sector. The most rapidly increasing consumption is also found in these two sectors.

The developments in energy demand can be described as follows:

- during the periods prior to launching of the series of Five Year National Development Plans (REPELITA), energy demand growth rate was 7.4% per annum.
- the average annual growth in energy consumption in each REPELITA have always been higher than the average annual economic growth

The high growth rate of the commercial energy consumption is the result of several factors, the major factors being.

- the expanding investment in energy intensive industries
- the rapid growth rate in electric power generation
- the growth of the population

2.2 Energy Conservation Program

The government has planned a national program on energy conservation consisting of four parts:

- public education and campaign
- technical information services
- laws and regulation
- research, development and demonstration

The first part of the program was launched in early 1980, the objective o which was to create public awareness of the Indonesian energy problem, and educate the general public on the importance of energy conservation.

Towards the end of 1983, the second phase of the programme was started by implementing an in depth energy audit and analysis in selected energy intensive industries, power generation and distribution, transportation and commercial sectors The result will be used to identify potential energy savings and to identify needs and problems to establish the basis for the following phases

It is believed that it would be logical to start with laws and regulations in the industrial sector, as it would be in the best interest of industries to save energy to cut production costs.

The government has established a permanent national committee on energy conservation with a comprehensive tasks that include formulation of laws and regulations, guidelines, and [illegible] and now is in the process of issuing a Presidential Decree on Energy Conservation, and producing a master plan for national campaign on energy conservation

2 3 Environmental Issues Related to Energy

A view of the identified and observed environmental effects related to energy development in Indonesia is presented in Table 2 2

2 4 Energy Policy, Planning and Ir[illegible] Framework

Energy Policy

The development in the energy system have taken place within an energy policy setting, the implementation of which has the following basic features

- process of the energy is regulated by the government
- declining share of domestic petroleum consumption is pursued, so that export volume of oil can be maintained or increased as targeted.

Table 2.2. Environmental Issues and Effects Related to Energy Development and Utilization.

Env. Area	Environmental Problems	Environmental Issues	Affected Areas
Air	Air pollution - particulates (dusts) - Carbon Monoxide - Carbon Dioxide - Hydrocarbons - Lead - Nitrogen Oxides - H2S - Acid Precipitation	Urban air pollution due to transportation, and dust Lead Human uptake Urban pollution Geothermal development Urban & Power Plant	Major cities in Java; Jakarta, Bandung, Surbaya, Semarang, Medan Major cities in Java; Jakarta, Bandung Bandung Dieng, Kamojang, Mt. Salak Mura Karnag, Jakarta
Water	Oil Spills Brines/Organics Acid mine drainage Heat discharge Loss of habitat	Marine pollution coastal pollution Coal mines Thermal pollution Hydrologica Balance Coastal pollution	Offshore areas, tanker oil refineries Oilacap, Dumai, East Kalimantan, Ombilin, Bukit Asam, East and south Kalimantan Power plant effluent in Jakarta Bay West, Central, East Java Bontang Bay, Jakarta Gulf
Land	Land disturbance Aesthetic Bligh Loss of habitat Subsidence' Leachate Storage/Disposal waste	Land use transformation, deforestation, environmental hazards sold waste	Coal mine areas, Power plants, Hydropower, Onshore oil Coal mine areas, Energy processing and conversion
Social	Population	Resettlements	Hydropower Development

energy conservation in promoted, but there have not been any effective policy measures in support the policy objectives.

policies on natural gas utilization and pricing is not specifically and explicitly formulated in a comprehensive way.

Concurrent with the objectives and priorities of the national development, the policy on energy development has the following orientation;

- energy development and utilization are to be directed towards prudent and efficient management of energy, with due considerations to the growing energy need, opportunity for export, and the long term sustainability of energy resources; efforts for diversification through enhancement in exploration, utilization and wider social acceptance of alternative energies are to pursue.
- within the framework of managing energy efficiently, conservation of energy, particularly with respect to depictable oil derived energies is to be pursued through, among others, appropriate pricing policy, the use of energy efficient systems, and campaign foı lifestyle that prevent from wasteful use of eneıgy, the development of alternative energy source has to be puısued with due consideration to safety, sustainability of natural resources and the environment
- the national capability and capacity in science and technology on the supply and utilization of energy has to be pursued through research and development, education and training
- development of the powı sector has to be continued to induce economic activities and to support human resources development in the rural area, the proper exploitations are to be promoted to conserve petroleum consumption and to avoid environmental degradation
- to assure and strengthen national resiliency in coping with future development needs through proper management in the supply and use of energy

To achieve the policy objectives and the specific targets in shifting the eneıgy mix towards lower share of oil, a set of policy programs aıe defined, that are designated as intensification, diversification and conservation programs

- Intensification program

What is meant by this program is that suıvey and exploration of energy resources are to be intensified to increase the level of economically exploitable energy reserves.

- Diversification program

In the program, the declining share of oil in the domestic energy supply mix is to be pursued through replacement with other domestically available resources

Conservation program

This program is considered as a mean of improving the efficiency of energy use and is regarded as being supportive to the pursuit for realizing equitable development process. This program also is intended, as its objectives, to safeguard the sustainability of natural resources and to achieve more balanced developments in pursuit for economic growth, equity, and environmental protection.

In line with the above program objectives, the functioning of technically and economically efficient, and environmentally sound technology in the production sectors and in the use of energy resources is to be promoted and developed.

The priority ranking for energy development in the near future is as follows:

- hydro and geothermal
- coal and natural gas
- new and renewable energy

The general policy on energy also include, as its component, considerations concerning the creation of better climate for energy developments and environmental management aspects. Regarding improved and supportive climate for energy development, the policy specially points to the importance of:

- capability enhancement in support of the development of energy industry
- appropriate investment climate and energy price

Regarding environmental issues, the general policy on energy stipulates that the sustainability of environmental bearing capacity and environmental functions must be maintained by way of:

- diversifying the supply of energy
- enhancing conservation measures
- developments of local resources based energy supply to enhance regional energy resiliency and reliability and to minimize disturbances to environmental functions and bearing capacity
- alleviate environmental pollution around abandoned energy mining and development sites through proper land reclamation and rehabilitation
- prevent negative social effects in undertaking energy development projects

Energy Planning

Energy planning in Indonesia is undertaken within the realm of the national development planning exercise. The national plan on energy development is covered under development plan on mining and energy.

The main responsibility for producing the plan formulation in the energy sector is the Ministry of Mines and Energy. Inputs for the planning formulations are taken from the major energy state enterprises, namely PERTAMINA (oil and gas), PLN (electricity), the coal state enterprise and PGN (gas utility), and from other ministries. Other major agencies that are supposed to contribute important inputs are BPPT (technology) and BATAN (nuclear).

The formulated plan would then go to the BAPPENAS (the National Planning Agency), where it is synthesizes and integrated to become a component of the five year national development plan

With reference to the REPELITA, yearly detail planning, mainly in relation to public sector activities and yearly planning government budget preparation, is carried out, the plans are translated into specific programs and projects The planning for implementation of the programs and projects still require considerable improvements

On the supply side, the choice of reliable and efficient systems and environmentally less damaging technology, in addition to economic considerations, is extremely important in response to the demand for rapid expansion. There is also considerable room for reduction of transmission and distribution losses. On the demand side, there is even more room for better management.

Considering that, being a developing country, Indonesia sill have to struggle in coping with problems in dealing basic development imperative, the available resources that can be allocated for technology development is highly constrained In the efforts for improving the performance of the systems in the power sector, requisition of the required technologies by way of technology transfer would be the best, if not the only, available option.

The lack in coordinatory functions to cope with incoming initiative and to anticipate situational changes, and appropriately and timely incorporating these to the on-going plans, as well as for long term considerations are observed

Institutional Framework

The energy policy is discussed and approved by the 14 member of the National Energy Coordinating Board (BAKOREN).

The draft policy formulation were prepared by the Technical Committee on Energy Resources (PTE). Originally, the scope of work of the PTE were:

- to review and study future energy issues and based on which formulate national energy policy
- to collect all reviews, formulations, suggestions, and programs, and submit them to the Chairman of the Natural Resources Committee
- to monitor all the follow-ups of government decisions on energy matters and submit appraisal concerning those follow-ups

The implementation of energy policies is the responsibility of the various government Ministries and agencies concerned. The responsibilities including energy planning, resources deliniation and development, oil and gas exploration, production and marketing, and development of coal, geothermal and power sectors.

Within the government establishments, energy research and development are carried out by several institutions.

If one look at the structural side of the Indonesian energy policy and planning institutional framework, one can say that the necessary institutional elements are in place. What is the most lacking is the establishment of strong coordinatory support systems and the operationalization of an effective and productive technical support systems, that deals with data maintenance, in-depth analysis, and preparatory ground works in producing policy and planning formulations. There are no specially assigned resources on a full time allocation bases for all these functions.

These weak points also results in the bias towards the supply side in planning considerations and, therefore, inadequate attention to the demand side management. A balance supply and demand considerations, that should also take environmental factors into account, would require considerably higher capacity in policy analysis and planning exercises.

2.5 Concluding remarks

From the previous description, one can conclude that an area that requires considerable attention in energy development is the power sector. With respect to the power sector, a great deal of effort is required, both in terms of capacity expansion and in terms of efficiency improvement.

3. Major issues in technology transfer processes

Prior to analysing the problem of technology transfer of co-generations systems, the general issue of technology transfer will first be reviewed In doing so it is necessary to lay out some analytical framework upon which the issues will be look at in perspective.

This section, therefore, begins with a brief elaboration of the analytical framework that will be used as a frame of reference in delineating relevant issues and in guiding the analysis that will be made in subsequent sections, where the subject of technology transfer of co-generation systems will be analyzed.

Subsequently, relevant issues concerning technology transfer in Indonesia will be discussed in terms of a set of identified major parameters defined in the previously mentioned framework Finally, a discussion that focuses on technology transfer in the power sector, where co-generation is part of, will be given

3 1. Analytical framework

In discussing transfer of technology, first it is important to have a clear conception of what is meant by [illegible] Essentially technology is information The set of information that can be classified as technology are the ones that describe human knowledge on the creation of systems. As such, technology can be viewed as a subset of scientific knowledge that concerns with the creation of things, as distinct from the other subset of scientific knowledge, namely science Science concerns with the description and explanation about the structure and behaviour of systems, whether natural of human institutionalized systems

The content of the set of technological information is growing dynamically, in line with the dynamics of human endeavours for the creation of things, that can be useful or not very useful, and many may turn out to be damaging

When technology as previously conceptualized is operationalized, there will be functional systems Such systems are more appropriately designated as technological phenomena Technological phenomena can appear in different forms, such as physical functional systems, organizational systems, practices and prescriptive informational systems, such as design drawings, operating manuals, management techniques, material specification, work procedures, etc It could also be extended to include skills and expertise or individuals having the distinct feature of being skilled and expert, or otherwise knowledgeable in technological matters[1]

All those technological phenomena, however, are carriers of technology The Asian and Pacific Center for Transfer of Technology of ESCAP grouped the information content of those various technological phenomena into four categories[2], namely:

- object embodied technology, designated as technoware,

- person embodied technology, designated as humanware;
- document embodied technology, designated as infoware; and
- institution embodied technology, designated as orgaware.

Following the above conception on technology, transfer of technology is essentially a process of flow of information on human creativity in producing functional entities, that takes place among and through institutional entities. Upon capture and accumulation within those institutional entities, such flow may result in the generation of physical objects, or working arrangements that (for some reasonable or unreasonable reasons) are valued as useful in support of human moods or desires. The information transfers can be physical entities like capital goods, or individuals, or data carrying media like engineering drawings, or institutional working arrangements like corporates.

The underlying problem that arise in relation to the previously mentioned technological information flow basically stems from the fact that: (i) the information transferred is a valuable one, embodied in systems or prescribing systems capable of creating benefits, or wealth, or influencing societal behaviour; and (ii) the effort to generate the information and the process of its embodiment of into functional entities require a certain amount of allocation of resources (human, matrial and funds).

It is natural that the generators and providers of the information expect compensation for the resources spent to generate and package the information, and also certain rewards for the effect that the functionalization of the information can have in creating benefits or wealth.

Consequently, the recipient of the information must spend their resources to acquire that information. This party, in turn, will concern with the return of the resources spent. This return is expected to be generated through the functioning of the acquired information.

It is therefore apparent that, in spite of other considerations, the key issue to be realized in dealing with technology transfer is that it is basically a process of exchange where information is being traded directly. If the information trading occurs indirectly, such as when the information is already embodied in physical objects, the mechanism and institution of exchange is well established and well known. One will see such indirect information trade as commodity trade, where whatever problems that originally may have developed in the past have already been resolved. Such established mechanism and institution for direct information trade remains to come.

Besides the considerable void of established mechanism and institution, echnology transfer processes also have additional problem. There are certain

peculiarities about the commodity being traded in technology transfer processes. The following are some illustrations about such peculiarities:

(i) Technology, by its very nature, has the potential of inducing change in productivity; this in turn could affect cost of production, competitiveness, or economic gains of the buyer. Furthermore, it may also induce innovative processes that may lead to the development of capability of the buyer to make improvement of the particular technology, or generate other technology All of those may run counter to the interests of the provider or producer of the technology;

(ii) Since the essence of technology is information, and information acquisition is attractive only when the party that try to acquire the information does not completely master the subject matter contained in the information, the technology buyer has to face the risks of not getting what he really wants On the other hand, the seller would not release the essential information, since otherwise the attractiveness will be lost

Having elaborated on the essential nature of technology and transfer of technology, the core of the subject matter of this sub-section, i e the analytical framework that will be taken as a frame of reference for analysis in this study will be developed and outlined

3.1.1. The structure of technology institution system

The structure of systems wherein [illegible] transfer processes take place has some generic features

Figure 3 1 delineates the generic features of systems in which processes of innovation that leads to the functioning of [illegible] systems in productive activities take place Transfer of technology takes place inside and through the various elements of that structure

As can be seen in Figure 3 1, the basic elements that accommodates and drive innovative processes are science and technology (S&T) institutions, professional institutions, industry institutions, and the market Except the market, the other elements are directly involved in technology transfer processes are all of the other elements mentioned

The industry institution has two distinct components, [illegible] as technology industry and commodity and services industry The last is part of the industrial system that concern with the production and delivery of goods or services, but does not generate or produce the prescribing aspects of the goods or services that those industries deliver to the market The other element is introduced to designate part of the industry institution that translate and package S&T research and development results into technological prescriptions

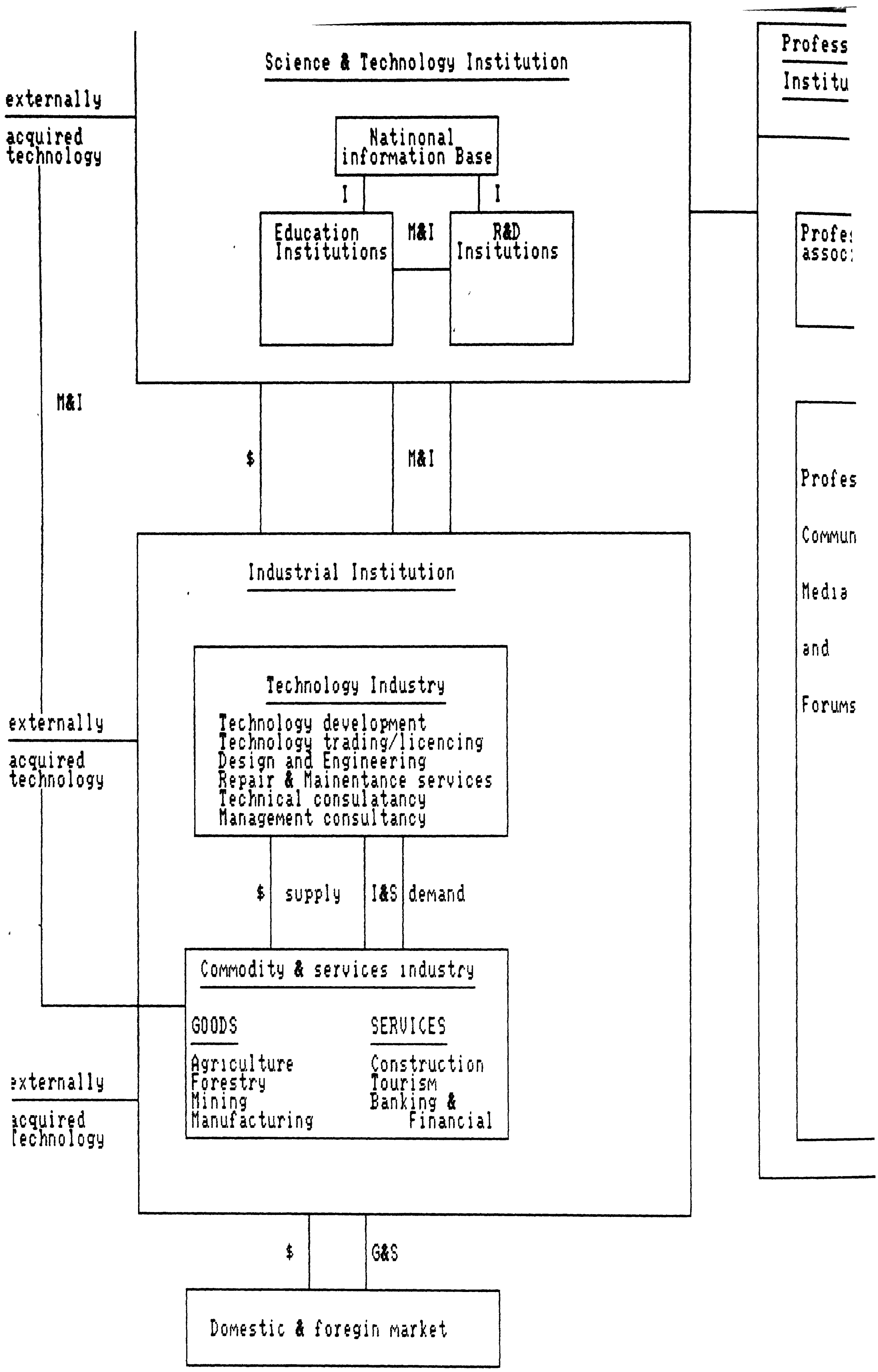


Figure 3.1. Schematic representation of innovation processes system
$ - money M - human resources I - information S - services; G - good

that can be operationalized in the production and delivery of goods and services that are found in the commodity and services industry.

The technology industry is the key element in the structure that determine the technological capability of the described system, since it is the place where information is processed and packaged into prescriptive informational packages that are useful and implementable in production activities.

3.1.2. Patterns of technology transfer

The technological components being transferred can originate from sources internal or external to the described system. The transfer of technology originated from sources external to the structure is part of the international transfer of technology (ITT) process.

With respect to the system under consideration, such transfer (i.e. ITT) will be designated as horizontal transfer, for the simple reason that the direction of the externally acquired technology flow is indicated as horizontal flows The transfer of technology originated from internal sources, as is drawn in Figure 3 1, basically flows in the vertical direction, and is therefore designated as vertical transfer. For internally generated technology, the spark of the innovation that leads to the generation of a certain technology could take place in any of the elements of the indicated structure, but the flow will always take place downwards

Externally acquired technology

With respect to the externally acquired (i e foreign) technology, the entry point could be at any level, but the dominant technological components acquired are different for each entry point The cost involved are also significantly different.

If the transaction occurs at the S&T and professional institutions, the dominant components being transferred are humanware and infoware, and mostly involves open information The cost consequences of the transfer is lowest as compared to flow entering to the other element, namely the industry institution However the outcome of follow-on activities that will eventually result in productive commercial operation is uncertain and undetermined.

The transactions which take place at the industry institution can have two different entry points, namely to the technology industry, or to the commodity and services industry

If the entry point is at the technology industry, the technological components being transferred is dominated by humanware and infoware, as in the case with the transactions taking place in the S&T and professional institutions But, in addition, it can also include substantial level of transfer of

orgawares. Furthermore, the cost required for this particular transaction is considerably higher. The effectiveness of the transfer, as measured by the quality and intensity of subsequent transfer to the commodity and services industry, is predominantly governed by the level technological capability of the recipient.

The flow of externally acquired technology that takes place at the commodity and services industry are generally most costly, and dominated by technowares and orgawares. A nation's lack of technological capability can be detected by the high proportion of externally acquired technology at this entry point.

In most developing countries this type of transfer generally leads the other transfer mechanisms. The major reasons are.

i. in the process of industrial development the most felt need is the supply of basic goods and services and to set the industry in motion; technology acquisition is, therefore, made by way of purchase of capital goods;

ii there is generally lack of technological capability to cope with the more sophisticated or less ready-to-operate type of technological forms; e g capital goods vs. equipment drawings.

iii this type of transfer is most preferable to investors, either domestic or foreign, since from any investor's point of view the motivational base for capital investment certainly is not technology transfer, but to capture market opportunity and to secure market share of their products,

iv. considerations concerning scarcity of capital and technological resources, investment risks, gestation time for effective delivery of the services that the technology is expected to offer, make this type of transfer more appealing

In the course of operating the acquired [illegible], when problems appears and more experience is gained in dealing with the technology, the need for support systems such as repair and maintenance, trouble shooting, technical advise are felt, and demand for such services are growing Such demand will induce business opportunities and ventures in technical services that are within the realm of what was previously designated as technology industry. Otherwise the situation will motivate such endeavours through different channels, such as government initiated establishments or enterprises, or through the imposition of regulations that force the establishments of the above mentioned technical services Eventually it may lead to the development of design and [illegible] as well as internally generated technological

prescriptions, either on newly developed technology or the improvement or adaptation of the externally acquired technology.

Internally generated technology

Technology transfer processes involving internally generated technological systems can be seen as a separate process parallel to those involving externally acquired technology, or else can be considered as part of the overall transfer process.

As one consider many interacting systems, each has a structure as the one described in Figure 3.1, then the second point of view is more appropriate. Processes within each structural system boundaries can be considered as part of the overall transfer process among the interacting systems. The system boundaries may coincide with national boundaries, corporate boundaries, or other entities carrying such technology institutional structure.

Transfer processes among the systems mainly contains information flow processes through various exchange mechanisms The processes taking place inside the boundaries of each system comprises many process elements, that include decisional processes concerning the allocation and exchange of resources related to technology development or te[illegible] acquisition, processes for technology marketing, dissemination for acquisition, and processes that are directly dealing with the development, maintenance and operation of technology

Concerning the last group of processes, i.e technology development, maintenance, and operation, if the particular technology originated from sources outside of the system boundaries, the following terms are often used:

a. adoption, if the technology, upon acquisition, is made to function as is received,

b absorption, if in the course of operating the t[illegible] increasing comprehension and mastery of the technology is taking place,

c. adaptation, if modification is undertaken to make the technology more suitable to the environment where it is made to function

When adaptation and absorption are taking place, further effects may occur that leads to the stimulation of te[illegible] development in areas around the acquired technology The confidence that evolve with the development activities may also lead to the stimulation for the developments of other technologies

3.1.2. Mechanism of transfer of technology

Figure 3.2 provides a visualization of the structure of the mechanisms of the previously described processes. It is shown in that figure that there are

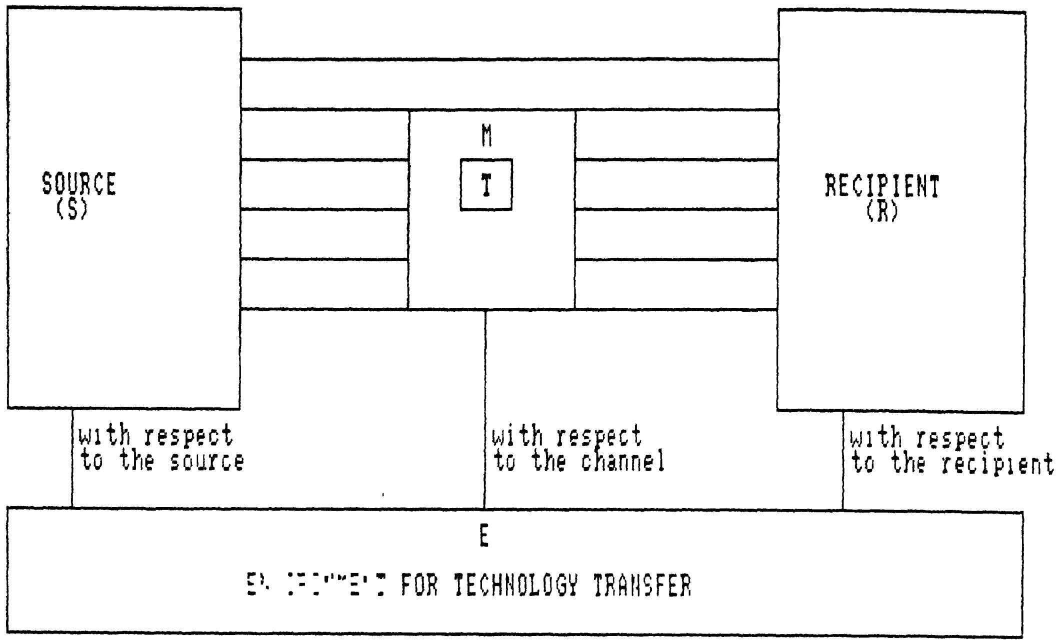


Figure 3.2. The structure of the basic elements in the mechanisms of transfer of Technology; T - technology component, M - medium, C - channel, S - source, R - recipient, E - environment.

basic elements to be considered in analysing transfer of externally acquired technology, namely : the technology being transferred (T), the medium that carries the technology (M), the channel for the transfer (C), the source of the technology (S), the recipient of the technology (R), and the environment in which the transfer processes take place.

Some elaboration will be given concerning the terms previously mentioned for clarification. Technology component is the particular technology being transferred; in this particular study the technology in question is co-generation technology. The medium is the carrier of that technology and appears as capital goods, management contract, technical assistance contract, training, documents, experts or skilled person. The transfer from the source to the recipient will take place through transfer channels, such as investment, technical assistance program, or development aid programs. The environment for technology transfer are laws, regulations, procedures, business practices, general economic conditions, wages, income level, as well as level of technological capability of the work force, R&D institutions, and educational institutions Policies on development, trade, energy, and other development sectors are also important elements that influence technology transfer processes.

The analysis in this study will be focused on the evaluation of selected parameters of the previously mentioned environmental factors

3.2 An evaluation on main parameters affecting technology transfer processes

Of the many parameters affecting technology transfer, the ones to be considered are · economic development, financing and fiscal policy, business environment where the policy on investment are also elaborated, banking and financial systems, investment financing, and the technology institutional set up and level of capability

3.2.1. The general environment for technology transfer

Salient features of the Indonesian economic development

In the seventies, mainly due to the high oil prices in the international market, the country experienced relatively high economic growth of around 7.8% per annum When there was considerable drop in oil price, lower economic growth was experienced with the average annual growth rate in the eighties is around 5.7%.

Beginning 1983, a series of economic reforms were made by the Government in reaction to the declining oil revenues. In general they are directed to develop and promote exports of commodities other than oil and gas,

particularly manufactured, agricultural, and forestry products. With the series of economic reforms, revenues from exports of these other commodities have been steadily increasing and in 1987 export revenues from these other sectors surpassed that from export of oil and gas.

A deeper look at the structure of the import and export figures will reveal that:

- The share of imports of capital goods is close to 20% of the total import values;
- about 70-80% of the imports are purchased of capital goods and other major industrial inputs in the form of manufactured commodities;
- while since 1987 revenues from exports of other commodities have exceeded that from exports of oil and gas, one can observe that for commodities other than oil and gas, the balance of trade has always been negative

Foreign exchange revenues from export is therefore an absolute necessity for acquiring the flow of technology in the form of capital goods, technical services, and commodities for industrial inputs When demand for export of manufactured products started to develop, the demand for capital goods, techical services, and commodities for industrial inputs were also accelerated; this implies the importance of devising measures to enhance technological capability and capacity for more resilient economic and industrial development Within the past decade, efforts in that direction are more seriously considered and undertaken in the development process. In the past few years there are also indications that stronger linkages between the agricultural and industrial sectors are pursued; this may eventually lead to improve the level of income of the majority of the population, as about 55% of the labour force are employed in the agriculture sector

The manufacturing sector has grown more rapidly compared to the other sectors since 1983, albeit the relatively strong dependency to imports of technology

During the on-going development plan, the overall economy is expected to grow in real terms at an average annual rate of about 5% Provisional estimates indicate that the industrial sector will, on average, grow at the rate of 8 5% per annum, followed by the transport and communication sector at about 6 4% per annum, and the construction sector at about 6% per annum. At the same time, the agricultural sector is expected to grow by about 3.6%, mining by about 0 4% and other sectors by about 6.1% per year

Consequently, by the end of 1993, the basic structure of the economy will have undergone changes. The share of agriculture in GDP is expected to decline from 23.3% in 1988 to about 21.6% in 1993, follows by the mining sector from 15.9% to 12.6%. On the other hand, the share of industry is expected to increase from 14.4% to 16.9%, followed by transport and communication from 5.7% to 6.4%, construction sector from 5.6% to 5.8% and other sectors will increase from 35.2% to 37.1%. With an expected annual population growth rate of about 1.9%, the annual GDP per capita is expected to improve from US$ 424 in 1988 to US$ 706 in 1993.

Regional disparity and population

The population of the country is estimated to be 179 millions in 1990. Population growth rate has been declining in the past two decades (1970-1990), but the present level is still relatively high about 2 2% per year. The growth rate is expected to drop to 1.9% during REPELITA V. Partly due to this relatively high population growth rate, but more important is the limited capacity of the economy to provide employment opportunities, unemployment is still a problem. It is estimated that new labour force seeking jobs during the current 5 years development plan (which started in 1989) is 11.9 million; with an expected annual average economic growth rate of 5%, the economy may be able to provide only 11 4 millon of new employment opportunities. Therefore, it is expected that about half of a million people will remain unemployed

It is estimated that about 55% of the work force are in the agriculture sector, where the level of income is generally lower than those in the industrial sector In combination with the proportion between urban-rural population (30% to 70%), the situation creates pressure for increasing urbanization.

Another important issues is the unbalanced population density distribution among the regions In 1985 Java has a population density of 755 population/km^2, Sumatera 69, Nusa Tenggara and Bali 106, Kalimantan 14, Sulawesi 61, and Maluku and Irian Jaya 6, with the average population density is 85/km^2

Financing and fiscal policy and business environment

Financing policy

In the 1970s and early 1980s, expanding oil revenues enabled Indonesia to sustain a policy framework characterized by large public investment in capital intensive infrastructure and industries, together with a trade regulatory regime that stifled competition.

Adjustment program which was launched in 1983 is designed to promote more competitive economy, with increasing role of the private sector and less

dependency from the oil and gas sector. Thus the macro-economic measures of the program are targeted not only at stabilization objectives, but also at reducing direct public involvement in production and sustaining competitiveness of the economy.

In parallel with those, the government has initiated deregulation in the industrial sector by simplifying and relaxing the multitude of domestic regulations and licensing procedures that constrianed the performance of the industrial sector.

In 1986, the number of areas to private foreign and domestic investment was expanded substantially and only a limited number of areas that are announced in what is called negative list were restricted. With the introduction of this new list, practically all sectors are now open to foreign investment. Foreign investment are also given greater access to domestic capital and financial institutions, and domestic partner ownership requirements are eased, only 20% of the total US$ 250,000 as minimum requirements of investment.

The applications of foreign investment are handled under one roof and the procedure is designed such that the handling can be completed within 6 weeks. To promote and attract more foreign investment, the government gives some tax facilities, in the form of tax exemption or delayed payment

The inflation rate was relatively low during the past two years, i e. 5 4% and 5 97%, but has gone up considerably towards the end of 1990. The government has targeted to achieve an average 5% inflation during the REPELITA V.

The banking and financial institutional system

The banking system in Indonesia comprises a central bank, namely Bank Indonesia, and state-owned commercial banks, private commercial banks, regional development banks, and other non-banking financial institutions Some private commercial banks are owned by foreign banks, and operate as subsidiaries or branches.

A series of policy packages effecting the banking system have been issued by the government The first was announced in June 1983, that allows banks to independently decide on the level of interest for their depositors and debtors without any major direction or involvement from the central bank Each bank must be capable of accumulating and allocating funds directly from and to the business community and the public

The policy package of October 27, 1988 was launched to achieve the following objectives

stimulating higher fund accumulation from the public

- stimulating drive for commodities other than oil and gas
- motivating efficiency improvements in the operation and management of financial institutes and banks
- improving the capability in controlling and implementing monetary policy
- creating a better climate for the development of capital market

The policy package of December 20, 1988 is mainly directed to the capital market, leasing institutions and insurances with the objectives of promoting the availability of alternative financial resources to support the development and enhancing the growth of the production sector.

The major sustances of the January 20, 1990 policy package are:

- that the central bank will terminate several credit programs on due date
- that the commercial banks are obliged to allocate 20% of their credits on small business firms
- that the commerical banks must observe the legal lending limits in allocating their credits

Some dominant characteristics of the national banking system are:

- the banking system is dominated by state-owned banks
- operationally the banks are very centralistic
- their orientation are to the five big cities in Indonesia Medan, Jakarta, Bandung, Surabaya, and Semarang
- their decision to grant a credit put a high emphasis on the provision of collateral and less considerations on credit worthiness
- their own capital equity are relatively small compared to their assets

With the previously mentioned policy measures, the banking system has slowly undergone shifts towards better operations, and are forced to be financially healthier

a. Terms on loan for investment

The procedure to get loan for investment is relatively simple. Application for investment loan has to be submitted with a feasibility study If credit is in the category of one of the existing special programs, then fixed procedure and criteria has to be followed.

There is a specific financial scheme for each of the credit program category With the deregualtion or policy reforms, the number of these special credit programs are considerably reduced Each bank establishes its own procedure and criteria requirements, the normal five Cs considerations are applied, i.e. character of the management, capability of the management, capacity to earn profit, and capital.

The recent developments, the bank can accept a project that it finances if it considers that the project is safe in terms of its risks. There are also cases where several banks establish a consortium to finance an investment if:

- the amount of credit is too large to be handled by each of the bank
- the amount of credit exceeds the legal lending limit
- each of the bank does not have sufficient knowledge and experience to finance a certain business

Availability of long-term investment financing

The availability of funds to finance such long term investment is also hampered by their equity, which usually are small, even though some banks have gone public, other factors are:

- the banks are very reluctant to provide long term credit funds, even a high rate of interest
- depositors are hesitant to put their money into a long term financial contract

b. Changes in interest rate

Since the launching of the June 1, 1983 deregulation package, the banks have more freedom in setting the interest rates of money deposits as well as loans. The launching of the October 30, 1988 policy package, was partly aimed at controlling the tendency and it seems to have positive effects in stabilizing the interest rate level

In the effort to control inflation rate, the government has launched tight money policy towards the end of 1990 and this has brough up loan interest rate that ranges between 24-28% The continuing high interest rate has apparently undesired effect to the business world; the banks have responded to such development by taking joint initiatives to bring down the interest rate to lower levels The current level of interest rate is around 22-23% per annum.

Norms of business organization

There are four major types of business organization.

- limited liability company (PT), a corporate entity having shares with limited liability of shareholders
- joint and several liability of founders exist until the Deed of Establishment has been approved by the Minister of Justice
- joint and several liability of Directors exist until the approved Deed of Establishment is registered with the relevant local and published in the State Gazette
- a PT is managed by a Board of Directors (mandatory) which is supervised by a Board of Supervisors (not mandatory) The Board of

Directors and the Board of Supervisors are responsible to the General Meeting of shareholders

Limited liability company (PT) is the most relevant in modern business ventures

Taxation

The present tax laws of Indonesia comprises law no. 6/1983 on General Tax Provision and Procedures, Law no. 7/1983 on Income Tax, that are applied to individuals and organizations ; and Law no. 8/1983 on Value Added Tax (VAT) on Goods and Services, and Sales Tax on Luxury Goods, that is applied to business

The tax system is basically self-assessment system with extensive withholding tax provisions The tax authorities will not issue clearances unless adjustment in the form of Tax Assessment or Tax Collection Notices are made resulting from any tax audit within a period of five years from the date the payment was due.

The general features of the income tax law can be described as follows.

- tax subject under the income tax law
- resident tax subject and non-resident tax subject
- tax object is the world wide income

Taxable income of an organization or individual is arrived at by substracting allowable deductions and non-taxable income from the gross income The allowable deductions include·

- the cost of deriving, recovering and conserving
- losses which may in most cases carried forward for five years
- depreciation of the acquisition cost of property and amortization of costs incurred in obtaining rights and other costs that have a useful life of more than one year

A permanent establishment is subject to tax on taxable income above rates plus 20% on the after tax taxable income, subject to existing Double Tax Agreement (DTA)

The DTA generally provide for the avoidance of incidental double tax on certain income such as profits, dividends, interests and royalties, because they are derived from one DTA country and remitted to another DTA country. The existing DTAs follow international models for such agreements.

Presently Indonesia has concluded DTAs with the following countries·

- Netherlands	- Canada	- Austria
- Belgium	- Philippines	- India
- Great Britain	- Thailand	- New Zealand

- Germany
- Japan
- France
- Denmark

Value added tax in imposed on the rendering of services, imports, manufactured goods and all traded goods excluding retail at rate of 10%. Luxury sales tax is only once imposed on a wide range of luxury goods at the manufacturing or import level at rates of 10%, 20% and 30%.

Foreign investment

The basic legislation on foreign investment is Law no. 1/1967, that was subsequently amended by Law no. 11/1970. In these laws, foreign capital is defined as foreign exchange that is not forming assets and part of assets not procured with Indonesian foreign exchange reserves, and also reinvested profits which were free to be repatriated

As a general rule, the minimum total intended investment is set at US$1 million, with the exception that a minimum as low as US$250,000 is allowable for investment in sectors requiring little capital

- particularly labour intensive, export oriented projects and in such projects which are supportive the large-scale industry
- projects entirely aimed at exports

The maximum foreign equity share is 80% to be reduced to less than 50% within 15 years by divestment to local (national) hands There is an exception, whereby maximum initial foreign investment share of 95% is allowable to be reduced to 80% within 10 years and further to less than 50% within 15 years in cases where large investment of US$ 10 millions or more is involved or located at remote areas at 10 designated provinces, or if 65% of the products is for export.

Where investment is located in bonded areas and the product is 100% for export, the maximum 95% foreign share is also allowable

The government also provide investment incentives to foreign investors, these are fiscal in nature.

Foreign capital can also participate in business in Indonesia through.

- appointment of agents and/or distributors
- joint operations or cooperations agreements
- opening representative offices
- technical or financial assistance agreements, licencing agreements, etc

Investment in this category include business sectors in oil and gas, general mining, forestry, and finance and banking

Other particular factors to be considered

Besides the previously described parameters that set the environment for transfer of technology, other factors related to business practices are also shaping the environment, since technology transfer cannot be detached from business activities. Another important factor is protection of intellectual property rights and patent law of the country.

With respect to protection of intellectual rights and patent laws, one can only say that in the past ten years the government has undertaken steps and measures to strengthen the system; Act No. 6, 1982 was issued to replace an existing patent law that was dated from the Dutch colonial era. However considerable efforts still have to be done. The institutional set up is still in the making to be able to function and operate. The government enforcing apparatus and the judicial system, in particular, still requires a great deal of enhancement to be functioning effectively and properly.

Concerning factors related to business practices, the following quotations [*] can properly reflect the situation:

A number of factors converge to make Indonesia a challenging (some might say 'frustating' or risky) place to do business. The first is rooted in the country's culture. The way business deals are made here is, in truest sense of the word "foreign" to many who come to Indonesia from abroad (including many fellow Asians). Business deals are not so much based on carefully crafted legal documents (though these are certainly drawn up) as they are on the relationships and bonds of trust that arise between partners in a venture.

A second, and related, matter is the state of Indonesia's commercial code, some parts of which date from the Dutch colonial era, while others (particularly regarding land rights and transfers) are entangled in a morass of locally-based traditions reaching back centuries. The rule of law here is still very much in its nascent stages. As a result, alternative strategies to minimize risk and maximize your room for maneuver must be considered.

One clear upshot of these two considerations is that the standard ideas foreign business people tend to have about being able to resolve serious conflicts and disputes through the pursuit of legal principles and the enforcement of legal documents in a court of law can sometimes of be little

[*] Harvey Goldstein, 'Doing business in Indonesia' in Business in Indonesia, Richard J Mann (editor), Gateway Books, Toronto, Canada, 1990.

utility in the Indonesian context. The reason for this are again partly rooted in Indonesia culture.

utility in the Indonesian context. The reason for this are again partly rooted in Indonesia culture.

Eschewing litigation, the Indonesians prefer to solve disputes through what they term "musyawarah" and "mufakat". These words mean "deliberation" and "consensus" and the process often involves mediators and arbitrators who assist the conflicting parties in reaching an acceptable solution.

Another is that the average business person, no matter how skilled and successful in other contexts, is utterly unequipped to make this most fundamental of decisions. Whom should you choose as your partner? What requirements should your partner fulfil? What and who should be avoided? How does one even begin to search? The answer to each of these question is as different as the investments and business deals themselves It is for this most weighty of business decisions that you must seek advice and assistance. To fail to do so is to court disaster.

Despite of what were quoted, it is also mentioned in the same reference that:".... ..Indonesia is moving rapidly in the right direction and, as a result, tremendous business opportunities have been and continue to be opened up".

3.2.2. The channels and media for technology transfer

The channels for technology transfer, as was elaborated in the analytical framework, depends on where the point of transaction takes place, at the science and technology community, at the technology industry institution, or at the commodity and services industry. Of the three transaction points, only the last two will be considered. Possible channels for transfer in the direction of the two industrial institutions are:direct investment, joint venture, licensing, and technical assistance arrangement, whether on commercial basis or as part of a grant All these channels are available, and the basic features concerning investment have been elaborated in Section 3.2 1 Elaboration on technical assistance program is not necessary, as this type of transfer channel is normally handled by way of simple contractual arrangement Licensing [illegible] are usually made as part of the investment arrangement If it is a stand alone agreement, one has to be familiar with the legal aspects, the salient features of which have been described in the preceeding section As was pointed out the system is still developing and evolving.

All of the media described in the analytical framework are available as options. There is no particular that need to be elaborated on this aspect

3.2.3. Salient features of the recipient

With reference to Figure 3.1 there are three classes of recipients, namely the science and technology institution, the professional institution and the

industrial institution. Each of those entities has basic different features, corresponding to the roles that each has within the overall technological institution depicted schematically in Figure 3.1.

The science and technology institution

The science and technology (S&T) institution comprises three basic elements, the S&T information system, the educational system, and the R&D system. In Indonesia the practical need for such systems, except the educational system is not really felt by the community at large. As such, there is practically no allocation of resources by the private sector to establish and operate R&D units and S&T information base system in Indonesia. Establishments within the S&T institution in Indonesia are, therefore, almost exclusively government operated or in some cases run by some of the large state enterprises Private sector R&D is practically non existent.

Basically the S&T institution systems are accommodated within five organizational set ups, namely the university system, the government R&D organizations, the departmental R&D agencies run by various government ministries, R&D units of the state-owned enterprises, and R&D units of the private industrial establishments.

As can be observed in other developing countries, the university system (particularly sate universities) is the strongest element of the S&T institutions in Indonesia in term of manpower resources, outlook, and idea generating capacity and capability It must be pointed out that up to this point in time only about five or six universities, all are state universities, that have such strength Practically all other S&T institutions in the country are initiated from or by elements of the university system, and university people are always involved and play leading role in the process of establishing, and even operating, those institutions

While the university system has always been playing leading role in the establishment and operation of the various elements of the S&T institutions, meaningful R&D output from the system itself is minimal. Several factors can be accounted for, the important ones being

a the heavy teaching load that faculty members have to take, due to the tremendously increasing demand for higher education,

b the numerous challenges and opportunities that the faculty members have in applying their expertise outside of the campus;

c the low salary that the government can provide to university staffs,

d the very constrained financial resources available for R&D activities.

Besides the university system, comparable R&D activities are undertaken by government research organizations such as the Indonesian Institute of Sciences (LIPI), the National Atomic Agency (BATAN), the National Aeronautic and Space Agency (LAPAN), and several laboratories that are accommodated within a science complex known as the PUSPIPTEK (National Science and Technology Development Center), and the Agency for Technology Assessment and Application or better known as BPPT. These research organizations, while not burdened with educational function, are facing similar constraints as the universities.

R&D agencies of the various government ministries and R&D units that are operated by state and private enterprises, such as the State Enterprise for Fertilizer (PUSRI), the State Enterprise for Oil and Gas (PERTAMINA), and the State Enterprise for Electricity (PLN) are functionally directed towards solving operational problems and to provide technical inputs required for planning purposes. In many cases their R&D efforts are contracted out to university staffs or other government research organizations previously mentioned.

At the national level, S&T development is administered by a specially established ministry, and the current ministry is designated as the State Ministry for Research and Technology. There is also a National Research Council (DRN) that has an advisory function to the State Minister for Research and Technology, and another higher advisory body called the Indonesian Academy of Sciences, that provides councel and advice to the President on national S&T matters.

With an institutional set up as previously described, almost all of the standard, formal government departments, councils and institutes are in place, defining a system that, in principle, addresses the full range of S&T requirements on the nation. However, as was partly pointed out previously, there are serious shortcomings in the operation and effectiveness of the system. The single outstanding aspect of the S&T institution with respect to S&T development of the nation is its ability in maintaining the growth and the spirit of the scientific community, without which the country would not be able to reach whatever progress that it has

The professional institution

In nurturing processes of innovation, professional associations play a key role in accommodating forums of communication among the actors the cut across the R&D and industrial communities. The functioning of professional

institution is therefore an important element in technology transfer processes, particularly in technology absorption and mastery processes.

Unfortunately, the professional institution is fuctionally weak. None of the existing professional associations in Indonesia are properly managed and functioning. Except of proceedings of meetings and conferences, one practically cannot find regular publications on S&T subjects produced by the professional associations. However, in line with the improving economy of the country, there are trends of improvements within the professional institution.

The industrial institution

As was indicated in Figure 3 1 and the corresponding elaboration, the industrial institution comprises two major elements, namely the technology industry system and the commodity and services industry system

Although horizontal (international) technology transfer also occurs at the other institutions (S&T and professional institutions), it is in the industrial institution that the need for externally acquired technology are strongly felt; mainly because of its tangibility and observable effects This is more clearly observed when the transfer process is taking place in the commodity and services industry

In terms of monetary value, the flow of externally acquired technology is highest in the commodity and services industry. As was already pointed out in the elaboration on the patterns of technology transfer, such phenomena are generally observed in developing countries Less intellectual sophistaication is required with such transfer process, since the technology is already will packaged and 'frozen' in functional and operable mediums such as capital goods, very detailed product design description and specifications, and operating instruction manuals, and usually is complemented with training.

Such technology transfer processes as exemplified in the car industry, fertilizer industry, cement industry, have shown to be effectively taking place in terms of the first level of technology absorption, which is the mastery of operating the technology by way of adaption of the acquired technology There is no observable serious problem in this process. The mastery for operating the technology has in fact stimulate further level of absorption processes, where what is known as progressive manufacturing process is taking place What is meant by 'progressive manufacturing process' is that in the course of operating the transferred technology, the flow of technological components that were originating from the source is progressively deleted and replaced by locally produced or generated components.

In the machinery industry, the process takes place by stages, started with gradual replacements of imported parts, and eventually, following a planned schedule, the development of new product designs is taking place. In the process industry, such as energy or chemical plants, the stages that take place are plant construction based on a given design, the development of the design for construction, and eventually the design of the whole system as well as the construction of the plant based on that design. This process also stimulates other transfer processes for the production of selected process equipment, following the progressive manufacturing scheme as previously described.

The described processes have taken place in many sectors of the manufacturing industry, and has resulted in the deepening of the structure of the industrial system of the country. Starting with the commodity industry, it goes to the technology industry, where engineering design and technology development and packaging are evolving taking place.

The evolution that takes place is increasingly stimulating the development of technology industry, and with that the demand for R&D activities is also evolving. These trends are currently observed, albeit only at the initial stages.

Concluding remarks

The above elaboration shows that technology mastery process that are initiated with the acquisition of externally acquired technology is taking place satisfactorily. With whatever limitation in human resources that the country has, there is adequate capability for the absorption process. The hampering factors are not in the domain of level of capability (either potential or real) but in terms of capacity, regulatory infrastructure, and some other parameters that set the environment for transfer.

3.3. Technology transfer issues in the power sector

In discussing technology transfer issues in the power sector, first a review of the development of the power sector is made. Issues pertinent to this study will then be identified and discussed. Of those identified issues, particular aspects that are most relevant to be considered in analysing the problem of technology transfer of co-generation system will be pointed out and assessed.

3.3.1. Review of the power sector development

The Indonesian power sector comprises: a) the State Electricity Corporation (PLN) with 9171 MW installed capacity (1991) b) captive plants installed by private and state-owned companies for their own use, with around

9000 MVA of capacity (1990), and c) a large number of cooperatives and small private establishments which generate and distribute electricity at rural areas. The Indonesian power sector is regulated by the Ministry of Mines and Energy (MOME) through the Directorate General of Electric Power and New Energy (DGEPNE). The Directorate is responsible for policy formulation, licensing of electricity undertaking and general supervision of the power subsector.

PLN (the State Power Company)

PLN is a public corporation assigned to act as the holder of state authority in the development of power sector throughout the country. Its responsibility includes planning, construction, operation of power supply and distribution facilities. Since its establishment in 1972 PLN has grown into an enterprise with around 52,000 employees, of whom around 2500 are university graduates. To support its development, PLN established 4 agencies namely Engineering Service Center. Education and Training Center, Electric Power Research Center and Management Service Center.

In line with economic development of the country since the seventies the electric sector has been growing rapidly. The installed power capacity of PLN in FY 1991/92 is 9,171 MW which is around seventeen fold higher as compared to that in 1969/1970 which was only 541 MW or grew at an average rate of 14.4% per annum. The power generating facilities of PLN (1991/92), in decreasing order, consists of oil (44.5%), coal (19%), hydro (24.5%), gas (10.9%), and geothermal (1.5%) power plants. The PLN's supply systems consists of over 1,000 individual systems, ranging in size from 100 kW to 4700 MW. PLN's service extends to all regencies and about 70% of sub-regencies in the country. Almost 70% of PLN's total capacity is located in Java, the most densely populated island of the country.

With such capacity growth the PLN's power generation during that period increased from 1,429 GWh to 30,000 GWh or at an average annual growth of 16%. In addition to this power generation PLN also purchases power from other entities. The share of purchased power on PLN's production (self-generation and purchased) tends to decrease from a substantial 25.5% (489 GWh) in FY 1969/1970 to only 2.2% (443 GWh) in FY 1991/92.

PLN's customer totals about 10 million comprising of four sectoral groups namely household (87%), industry (0.3%), commercial (3.6%) and public service (2.4%). Up to 1986, household sector had been the largest consumer of PLN's

supply and since then this position has been taken over by the consumption of industrial sector, indicating that electricity consumption has shifted to the more productive uses. Between 1982-1992 the relative share of household sector consumption decreased from 44% to 33%. In the same period the share of industrial consumption increased from 27% to 51%. However, PLN's relative share in industrial electricity consumption is still relatively low. In 1991 PLN's contribution in total industrial consumption is only around 42%, the rest being accounted fro by captive generation facilities operated by industrial plants In the last ten years the demand from PLN's industrial customers grew at an average rate of 22% per annum. In line with the rapid industrial growth, industrial electricity demand is expected to continue at high rate at least in the next ten years

One of PLN's impressive achievements is its rapid rural electrification program. The program was launched in 1978 and in 1979 PLN electrified a total of 280,000 rural households at 2,244 villages. In 1991 the total PLN's rural customer has reached 6.3 millions distributed over 23,000 villages. With total rural households of 28 millions and total village of 62,000 villages (in 1990), the rural electrification ratio, in terms of household and village, are respectively 22.5% and 37%.

In spite of its rapid development, PLN is only able to serve around 70% of urban household and 22% rural household (1990), whereas it is estimated that around 90% of urban household and 60% of those in rural villages could afford to purchase electricity.

According to PLN projection the Indonesia power demand in Repelita VI (1994-1988), Repelita VII (1999-2003) and Repelita VIII (2004-2008) will grow at a rate of respectively 17%, 12% and 8% To meet such demand growth PLN installed capacity is to be increased that at the end of each of the above mentioned repelita PLN's capacity would reach respectively 25 TW, 40 TW and 57 TW

Captive power

The unmet demand of electricity, in terms of quantities as well as quality, for industrial sector which rapidly grew in the late seventies has since lead to the rapid growth of industrial captive plants Excluding large captive plants (more than 200 MW/plant), the total installed capacity of captives has grown from 2,385 MVA in 1978/79 to 5,775 MVA in 1989/90. Almost half of the later are also connected to PLN and operating on standby basis. Including large captive plants the total captive power in 1989/1990 was 9000 MVA and about half of them are plants with installed capacity of at least 10 MVA per industry.

The PLN's share in industrial electricity consumption is only around 42% (1991); the rest being supplied by captive plants.

Unlike PLN's electricity system where it is concentrated in Java, more than half of captive plants are installed outside Java. Captive generators in Java is mainly diesel plants (about 80%). Outside Java captive power generators are more evenly mixed. It comprises of : diesel (44%); natural gas (27%); hydro (17 7%); biomass (6.6%) and oil/coal-fired power plants (4.2%). Biomass power plants are used in industries processing agricultural products like in palm oil and sugar industries and in wood processing industries (sawmills/plywood).

Rural electric cooperative and micro enterprises

Lack of PLN electricity supply in rural areas gave rise to the establishment of rural electric cooperative and micro enterprises In 1990 there were a total of around 20 rural cooperatives with total capacity of about 265 MVA serving about 40 thousand rural households. According to a 1986 economic census, there were a total of about 17 thousand small private utilities in 1986, each operating generator of 1 kW or more with at least 10 customers. The total installed capacity of this micro utilities was about 180 MW. Most of these utilities were household establishments without licence, serving low quality electricity and charging high tariff (4-8 times higher than PLN tariff). With such service these utilities could not compete with PLN and usually disappear when PLN reaches the region.

Other private participation in electricity undertaking is in the form of sub-contract services of private in the metering, billing and line installation of PLN's electricity systems With the objectives of reducing PLN's manpower deployment and to support rural development, in 1979 MOME and Ministry of Cooperative established four schemes (or Pola) in which village cooperatives (KUD) could participate in the rural electrification program, i e..

Pola I ·

KUDs are contracted by PLN to handle metering, billing and minor repair of PLN's distribution system,

Pola II .

KUDs install housewiring as contractor of to the customer; with licence and cost approved by PLN;

Pola III ·

KUD function as local distribution companies for PLN (KUD purchase bulk power from PLN and sell it to customer);

Pola IV ·

KUD generates and distributes its own electricity independent of PLN.

In 1990 the total number of KUDs that were involve in Pola I, II and a combination of Pola I and II were respectively, 602, 123 and 227 units. Up to now KUD involvement in Pola III does not exist. As previously mentioned in 1989/1990 there were around 20 KUDs operating under Pola IV. To increase the capability of these cooperatives PLN also provide training program for KUDs. Up 1990 PLN has trained a total of 989 KUDs.

Recently PLN introduced a new KUD-PLN framework designated as Management and Service Arrangement (MSA). In this framework KUDs are contracted by PLN to manage the operation and maintenance of PLN's isolated system. This framework is a further development of Pola I and II which are considered successful and is aimed to prepare cooperatives for the more advanced Pola III framework

Power shortage

The rapid growth of industrial sector and PLN's inability to keep up the pace with such growth, primarily due to financial constraints and delayed expansion projects, has been the cause of the prevailing power shortage. In Java, i.e. the most felt shortage region, the additional demand of industrial sector in FY 1991/1992 was about 2,500 MVA while in the same year PLN could only serve additional supply of around 800 MVA. The shortage was more felt during the long dry season in 1991 when the hydro plants (22% of Java capacity) could not operate optimally At present the reliability of Java supply system is actually critical as at normal condition the capacity reserves of PLN plants is only around 16%.

To not hampering industrial development, the government has been advising new large industrial estates to install captive power since PLN could only provide additional supply in 1993 when the large combined-cycle plant in East Java is expected to come on-line To speed up the availability of power this industrial estates primarily rely on diesel plants. In order to not burden the government the subsidy budget this industrial estates will have to pay imported fuel at the international oil market price.

Private power generation

A relatively new scheme of private sector participation in the electricity development is private investment in dedicated power plants The GOI has taken initiatives toward this direction and is currently arranging some private power generation projects In addition, the GOI encourages private investments in those situations where private generation is economically competitive to PLN's grid, such as (i) heat and power cogeneration, (ii) the utilization of waste

material for power generation, and (iii) the development of large scale power plants to meet specific industrial requirements and augument PLN supply.

Despite the provisions enabling the participation of cooperatives and private has principally been issued since 1985, the supporting regulations and rules for implementation are still lacking. The existing regulations or guidelines which is issued in 1983 and derived from 1979 regulation are basically administrative in nature. This comprises of procedural steps needed to be followed by parties interested in electricity undertaking. Provisions regarding the processing of proposals, especially on the pricing and guarantee issues has not been defined in those regulations.

To implement provisions stipulated in Law 15, 1985, which is of particular concern to private power, in June 1990 the GOI established as Private Power Team in charge of developing the lacking implementation guidelines and regulations to handle private power projects This team is an interministerial committee chaired by the Director General of DGENE and includes officials from PLN; Directorate General of Oil and Gas; BKPM (Investment Coordination Board); BPPT (Agency for Technology Assessment and Application), Directorate General of Taxation, and Directorate General of Monetary Affairs of the Ministry of Finance.

Presently this team is processing the first private power project i.e. a 1200 MW power plant in Paiton east Java possibly under BOO type of contract It is expected that lessons learned from this project could be further studied and used to develop comprehensive regulations, accommodating various range of plant scale, to deal subsequent private projects

Considering the budgetary constraint the Government of Indonesia expects the participation of private investor in the development of electricity sector. The investment for about 60% of new generation capacity for Java, which up to the year 1999 would require additional 13 MW, is expected to come from private sector sources. In 1991 the GOI has invited private investor to be involved in the development of another five projects which include coal, peat and geothermal plants with capacity ranging from 25-600 MW.

3.3.2. Technology transfer issues

As the national level there are nine actors that are involved in the processes of technology transfer, namely the State Power Company (PLN), the Industry, the Agency for Technology Assessment and Application, the Directorate General for Power and New Energy, the Department of Cooperatives, the rural electric cooperatives and micro enterprises, university

and government R&D organizations, and non-government community services organizations.

In terms of the scope of functions being undertaken, those actors can be categorized into three groups.

a. The first category are those in charge of determining the policy and guidelines that influence the choice of technology, where the particular actors are : the Agency for Technology Assessment and Application (BPPT), the Directorate General for Power and New Energy, and the Department of Cooperatives. Of the three government agencies, BPPT has a dominant role in technology selection and evaluation, particularly for government investment.

b. The second category are organizations that conduct R&D, develop technological systems, and disseminate technology by way of demonstration projects. Basically the type of technology that are dealt with are small scale technology, renewable resource based energy systems, energy conservation technology, and technological softwares. University and government R&D organizations, and some units of the agencies belonging to the first category (see point (a)) are elements of this second category of actors. Non-government community service organizations are mainly in dissemination through demonstration projects.

c The third and most important category are enterprises, large and small, that are directly involved in the investment and operation of power systems, and enterprises that manufacture machineries and equipments, as well as those that provide technical service like construction, installation, repair and maintenance. Some of the major actors are PLN, captive power generators in the industrial and service sectors.

The bulk of technological flow goes to this third category, where PLN and industrial captive power generators are the dominant ones. The mode of transfer is mainly by way of investment, and the teachnology being transfered are embeded in capital goods, engineering design and construction services. The level of mastery in the absorption process has only reach the ability to operate and maintain the installed system, part of the construction work, namely the structural part, and manufacturing of licence based static equipment such as boilers, heat exchangers, and burners

Energy equipment manufacturing

Technical assistance is still required in equipment manufacturing, namely in production, supervision, and engineering design. The design and

prescriptive aspects are completely adapted through licensing mechanism. The level of mastery that has been reached is really a reflection of the infancy of machinery and equipment industry of the country, which has only plant reached assembling operation and structural works. Processes that require forging and heat treatment is only beginning to develop. So is also the case with works involving skills and expertise on precision mechanics.

The rapid growth of the power sector contributed significantly to the stimulation for investment in energy equipments and machineries. However, in many cases the level of demand in terms of number of units is presently still too small to make additional domestic or joint venture investment attractive, production facilities that are inplace are still considerably underutilized especially those producing large scale equipments.

An area where transfer of technology related to electricity production is economically attractive is in the production of medium and small capacity diesel engine and electricity generetors, because of the large area of application in productive activities and also because of the unmet demand for need of electricity. The demand for high capacity units has not reached a level where investment for domestic production is attractive. The level of technological mastery in the commodity producing industry institution has only reached assembling operation of licenced desing Most of the essential components still have to be acquired from the source; economic considerations do not justify further stages of progressive manufacturing scheme.

Table 3 1 Provide some illustration on the development of diesel and generator machinery industry

Year	Diesel engine (Units)	Generetors (Units)
1973-74	2,000	-
1978-79	30,400	-
1983-84	52,775	3,771
1988-89	32,424	6,570
1989-90	46,500	7,790

Source Lampiran Pidato Presiden di DPR, 16 Agustus 1990

Engineering design and construction

Other areas where transfer of technology is economically attractive and processes of absorption is taking place are engineering design and construction. The activities are normally undertaken in connection with the implementation of power generation and distribution projects, whether part of an industry

construction project or electric utility project of PLN or private power generators.

Except for diesel powered generators, activities in engineering design and construction are undertaken by foreign firms in cooperation with local partners. By government regulation, such arrangement is to be compiled by any foreign engineering and contracting firms. In an evolutionary manner, as the capability and capacity are develping, local consultants and contractors are taking the role as the main contractors.

Technical studies and services

Technical studies for feasibility and preliminary configuration of power plants are mostly undertaken by domestic technical resources. PLN in particular, has in-house capability for such studies. Engineering capability for energy conservation studies and services for industry and commercial sectors are also beginning to evolve in the past ten years, but the progress is hampered by the subsidised prices of refinery products, natural gas and electricity, which are the major component of the energy supply of the country

The practices of those studies and services are based on externally acquired methodologies and techniques, whereby the support of computer based softwares has dominant role in accellerating the level of performance There is, however, a glaring deficiency of development efforts in generating those techniques and methodologies, either compoter based or not. The practiced techniques and methodologies are two or three generation behind from state of the art techniques, and therefore have not been able to address current issues where, for example, conserving measures in the demand sectors are to be accounted for in supply planning.

Waste heat recovery systems, commonly practiced in the process industry, has somehow been alient to those dealing with the power sector. Combined cycle and co-generation are only widely discussed and put in practice in the past five years The role of donor agencies are dominant in the introduction of such technologies.

Application of non-conventional mode of electricity supply

Following the sudden jump of oil price in 1973, a wave of grants and technical aids are coming to developing countries, including Indonesia, where non-conventional mode of power generation technologies are promoted by way of introducing or re-introducing revived forgoten' technologies Except for solar photovoltaic and fuel-cell based systems, the non-conventional aspect is really not the power generation itself, but the primary energy that are exploited or utilized to drive the prime-movers of the power generation system.

Among the array of promoted technology, the ones that were gaining wide spread attention in Indonesia are: biological digestion of biomass wastes, thermal gasification of biomass, wind mills, mini- and micro-hydro turbines, and solar photovoltaic cells.

Development works, adaptation, and straight demonstration activities of the technology are undertaken by university people, government R&D organizations, and even some government administrative offices dealing with energy. In terms of the previously described technology institutional structure (see Section 3.1 1), the entry point for the transfer of mostly externally acquired technology is at the Science and Technology institution. The area where the technology are being tested for application is the rural community or small and relatively primitive industries.

While there are islands of R&D groups that develop high level of mastery of the technology, the functioning of the technology in real application practically is not happening Three factors can be accounted for, namely.

a The channel of transfer is taking place through the R&D institution route. With limited resources that can the country can allocate for R&D purposes, the dissemination processes are mosly stopped when the external funding is receeding and discontinued

b The area of application where the technology is directed, i.e. rural environment and small/primitive industry, is lacking of nurturing capacity for the appropriate functioning of the technology

c The prices of established energy commodities against which those technologies are to compete is distorted, mainly due to subsidy

With a few exceptions, only when the technology is robust with respect to requirements for technical support, and there is a combination of agressive promotion by foreign donors and government support, would the technology able to function But this is, in fact, some form of subsidized scheme. Such situation is recently observed with the promotion of small solar panels of photovoltaic cells for individual rural families.

While small photovoltaic solar panels seems to be the only one of the array of technology on non-conventional mode of electricity generation being dealth with, the level of technological mastery of the technology is, relative to the others that were previously mentioned, the least

The only technology, within the category under discussion in this sub-section, where high level of mastery has been achieved and nearly competitive with established systems, and furthermore can survive under minimal technological support system is minimises hydro system The other technology

that have been highly mastered are biodigestion of biomass wastes, and biomass thermal gasification. Both technology are also nearly competitive against established systems, but both require certain level of technical efforts to operate; the requirement for biomass thermal gasification is considerably much higher.

Concluding remarks

The discussion concerning technology transfer issues in the power sector has been made by focussing on absorption aspect. The emphasis on that particular aspect is made, since other relevant aspects has been substantially covered in Section 3.2.1.

By also refering to the elaboration concerning the development of the power sector in Section 3.3.1, a set of conclusions that are most relevant in seeking justifiable opportunity for the application of co-generation system can be made.

a. The most effective route of technology transfer in terms of having the technology operating and responding to needs is to the industrial institution, where the flow is dominated by capital goods and/or packaged and ready for use technological prescription. The process of absorption towards technological mastery, however, is slow as compared to other routes.

b. For equipment manufacturing, there is less opportunity to develop economically attractive investment in the production of large scale units. The market is easily saturated, and can easily lead to under utilizaition of capital

c With reference to point (b), if one wants to achieve an objective through the introduction of technological means, e g improvement of efficiency of the energy system by way of promoting the wider functioning of co-generation system, it would be more appropriate not to focus to the manufacturing of large scale equipments.

d To avoid unnecessary failure, it is important to identify areas for the functioning of the technology that has the capacity to nuture the growth of the application of the technology and its further mastery.

e. Considering the average manufacturing capability, it is best that the initial effort should be focused on developing manufacturing of static devices, such as waste-heat boilers and heat exchangers, and through a progressive manufacturing scheme, moves towards the manufacturing of more sophisticated production precedures, such as the manufacturing of

rotating equipments and devices that requires wider capability base in precision mechanics, heat treatment and forging.

4. Technology transfer of co-generation system

After elaborating pertinent background considerations in the preceding sections, the key questions to be addressed in analysing technology transfer of co-generation system will be dealt with in the chapter.

As was pointed out at the outset, the investigation is focused to respond to the following questions:

(a) What opportunities are available for the wider application of co-generation systems in Indonesia?;

(b) What is and would be the role of international transfer of technology to Indonesia in influencing the wider application of co-generation systems;

(c) What would be necessary to promote a better environment for such transfer process to occur?

4.1 Opportunities for co-generation in Indonesia

As was previously pointed out (see Section 2) Indonesia has launched energy conservation program as one of the important componenets of the national energy policy. The energy policy is therefore supportive to efforts for the utilization of co-generation systems, although effective implementation of the policy has not been observed. The major barrier being the prevailing subsidized price of energy, particularly petroleum products and electricity.

Potential consumers of co-generation system products, i.e. electricity and heat, are the industry and commercial sectors. If one extend the analysis not strictly to co-generation, but considers the wider problem of waste heat recovery from power generation units, there are also considerable opportnity for the application of the technology in the power sector, namely to enhance the production of electricity generated by diesel powered plants. However, there is practically no demand for residential space heating, for the obvious reason that Indonesia is a tropical country.

4.1.1 Overview of the opportunities in various applications

Opportunities in the industrial sector

Since the last decade energy consumption of industrial sector has been the largest among sectoral energy consumers (commercial, transport and residential sectors). In 1990 industrial energy consumption accounted for about 40% of total commercial energy consumption.

Electric power demand for the sector is supplied by PLN (state electricity utility) and industrial captive plants. At least since the last two decades electric

power supplied by captive plants have been larger than that of PLN. In 1991 captive power plants supplied about 58% of the total industrial electricity demand. Although the share of PLN in the industrial electricity supply has been increasing with it's rapid capacity expansion in the last decade, one cannot expect that the growth of supply from PLN will be able to keep up with the pace of growth of the demand for electricity from the industry. Captive power plants will remain important.

Most of industrial captive power generators are thermal-based plants fueled with refinery products. More than half of this captive thermal plants capacity use diesel gensets.

Industrial process heat requirements are supplied by respective industry. At most industries that operate captive plants and have process heat demand, co-generation is still not practiced. The production of electricity and process heat are performed separately. However, co-generation systems have been long a standard energy supply system of palm-oil and sugar industries.

Opportunities in the commercial sector

In the commercial sector, particularly in commercial buildings (hotels, shopping centers etc.) electricity is supplied by PLN. For reliability reasons, however, such establishments, especially large commercial buildings, also maintain diesel power generators, operated on a stand-by basis.

Heat energy demand particularly for water heating exist in classified hotels. They usually operate electric heater or steam boiler for the hot water needs

Opportunities in the power sector

In addition to the industrial and commercial sectors, opportunities for the utilisation of co-generation systems also exist in the power sector. There are two possible schemes of modes of co-generation implementation in this sector. The first scheme is the utilization of heat energy released by PLN's thermal plants to supply process heat demand of adjacent industries. While such scheme is technically feasible, the implementation will not be easy as such scheme would require inter-institutional transactions.

In the second scheme, heat recovered from exhaust gas and water jacket of PLN's diesel plants is utilized to produce steam which subsequently be used for power generation using steam turbines The second scheme is, by definition, not a co-generation system since it produces electricity rather than heat, and is commonly designated as combined-cycle operation

4.1.2 Potential capacity of co-generation application

Industrial sector

Commercial energy consumption in the industrial sector in 1990 is estimated to be 140 mboe or 20 mtoe. Around half of it is natural gas and coal which is primarily consumed by 3 major industrial sub-sector namely fertilizer, steel and cement industries. Although these industries are large energy customers, they have to be excluded from the anlaysis since co-generation of atleast waste-heat recovery systems have been widely applied. The same applies to the pulp and paper factory that, based on 1990 data, consumes 5% of the total industrial consumption.

Among the remaining industries, the significant commercial energy consumers are the textile and food industries.

The textile industry consumes 10% of total industrial use of commercial energy, which amounts to 2 mtoe. The food indstry consumes 5% of total industrial use of commercial energy, or in absolute term is 1 mtoe. According to USA experience, for each mtoe of energy use in the food sector, the co-generation potential is 30 MWe. Therefore it is estimated that the co-gen potential in Indonesia food sector is around 30 MWe

In the textile industry around 70% of fuel consumption goes to electricity generation, in which air conditioning accounts for a significant energy consumption Assuming that air conducting could be performed using absorption chiller instead of electric chiller, the co-gen potential as percentage of the total energy consumption could be as high as that in food sector, where fuel for electricity generation is about the same with that of for heat generation. Applying that assumption, the co-gen potential in textile industry is estimated to be 2 mtoe x 30 MWe/mtoe, which is 60 MWe

Commercial sector

Classified hotels have the potentials to utilize co-gen system for their electricity and hot water need There are around 430 classified hotels in the country, 69 hotels of which are rated as 3-star hotels or higher, with following breakdown; 3-star=44, 4-star=15; and 5-star=10 hotels.

Those hotels normally get their electricity supply from PLN and have diesel gensets as stand-by systems The total stand-by unit capacity of the 69 hotels is estimated to be 25 MWe, and therefore is the co-gen potential

Power Sector

PLN (the State Electric Utility Company)

PLN has around 1800 MW diesel plants. If they were retrofitted with waste heat recovery systems and operate as steam topping combined cycle there would be an additional capacity of 600 MW, based on the assumption that

efficiency of diesel plant is 30%, and the efficiency of diesel combined-cycle is 40%.

Captive plants

The total capacity of the existing industrial stand-by units is estimated at 2100 MW, and these are diesel units. If and when those were operated as combined-cycle to supply their own demand and sell excess power to PLN, the latter could supply an additional electricity of 2800 MWe; i.e. 2100 MW of avoided supply from PLN to those industries and 700 MW of additional capacity due to the purchase of generated electricity from diesel combined-cycle operation.

The total capacity of currently operated captive diesel power plants is 2100 MW. If and when these units were converted into diesel-combined cycle, the capacity would be increased to 2800 MWe. This would create an opportunity for PLN to acquire an additional electricity supply of 700 MW (2800 MW - 2100MW).

Industrial estates

According to government (Directorate General of Electricity and New Energy) projection the additional electricity demand for industrial estate within 1989-1994 in Java will be around 1300 MW. Assuming that PLN could only supply one half of it and the rest would be supplied by captive plants, the co-gen potential in this industrial estates would amounts to 650 MW

Referring to the analysis on the opportunity for co-gen technology, elaborated in Section 4.1, an area where efforts could be interesting and attractive to be undertaken is the retrofitting of existing diesel power plants, both for the production of process heat, as well as power generation capacity enhancement by way of utilizing the recovered waste heat for combined-cycle operation. The latter scheme could contribute meaningfully to the current power shortage problem, particularly in the island of Jawa.

Agro processing industries

Co-generation technology has been practiced in Indonesia at major agro-processing industries i.e. sugar and palm-oil. The same is also true with the plywood and veneer mills Around 40% (60 MW) of plymills total power demand is supplied by biomass fueled co-gen systems. If the remaining 60% were switched into co-gen, potential in this sub-sector is estimated at around 90 MW.

Aside from the plymills, there are also co-gen potentials in the large sawmills, as they require both electricity and heat (for drying). The total co-gen potential in this industry is around 150 MW (around 50% of total power capacity of large mills in Indonesia in 1987)

4.2 The role of international transfer of technology and the transfer mechanism

The presence and the functioning of co-generation systems in various industries in Indonesia has taken place not because of the particular choice of that technology, but because the systems were offered as part of the technology package of the whole plant. This has been the case with co-gen systems that are found in some major chemical plants.

For agrobased processes like palm oil and sugar refining manufacturing, the use of the technology was introduced during the colonial era by the estates that operated such plants. When in recent years there was a boom in plywood and wood products manufacturing, most of the plants are not using co-gen system, although the plants need both heat and electricity. While the plants are using biomass to fuel their steam generation plants, their electricity requirements are supplied by diesel power plants

Apparently the advantages of having co-gen system is not quite appreciated, due to several reasons. First, because refinery products are easily available at low (subsidized) prices Secondly, while the notion about co-gen system is familiar to the business owners, they apparently do not quite comprehend what that system is, and therefore perceive the technology as being too complicated or too expensive, or otherwise is not regarded as a proven technology.

The above indicate that there are considerable efforts have to be undertaken to familiarize and demonstrate the technology. This is where, in the first stage, international inputs are required, and therefore the important role for promoting technology transfer processes for co-gen system in the country.

Several channels have to be exploited in the process, ranging from information dissemination processes, in the form of seminars, workshops and training, to further stages of dissemination in the form of real world demonstration, investments in technical services and devices manufacturing of elements of the co-gen systems.

As fas as efforts to develop domestic capability and capacity to support the functioning of co-gen technology, there are two technological components that should be most appropriate to be taken as the media to initiate the establishment of such capability and capacity. These are co-gen systems design, and licence based production of stationary components, such as heat exhangers and waste heat boilers Other more complicated system components and devices, like steam turbine could follow at later stages. If and when such co-gen

engineering business firms are functioning, they have to include also training component to customers as part of the delivery function.

Referring to the analysis on the opportunity for co-gen technology, elaborated in Section 4.1, an area where efforts could be interesting and attractive to be undertaken is the retrofitting of existing diesel power plants both for the promotion of process levels as well as power generation capacity enhancement by way of utilizing the recovered waste heat for combined-cycle operation. The latter scheme could contribute meaningfully to the current power shortage problem, particularly in the island of Jawa.

Another area is revamping of steam generation and power plants in plymills, that currently utilize heat and electricity, but are not using co-gen systems.

4.3 Developing conducive environment

In search of viable and feasible initiatives to promote and to support the implementability of the policy on energy, particularly with respect to energy conservation, whereby the application of co-gen technology can have significant contribution, a set of factors for developing conducive environment will be identified.

Having most of those environment factors in place, potential areas for the wider functioning of co-gen systems, as was elaborated in Section 4.1 can be taken as targets of implementing the system. Two basic criteria have to be considered in the final selection, namely

a the dimension of the beneficial impacts that can be gained at the national level, as measured in terms of the extend of contribution that such endeavour would have in realizing the objectives stipulated in the policy on energy; and

b. the economic viability and profitability, and therefore the attractiveness to business enterprises to implement co-gen systems, or to venture into the business of delivering co-gen systems

In terms of achieving the objectives stipulated in the policy on energy, the particular criteria most relevant to be considered are that, the investment to implement co-gen systems and to establish business ventures for delivering such systems have the following features·

a economically and financially justifiable

b. responding directly to the most felt issues in the energy problem in Indonesia; currently these are increasing level of consumption of refinery products and deficient supply of electricity

c. be implementable without aggravating the balance of payment situation of the country

d. prevent from any scheme that will sustain energy subsidy or lead to the wider spectrum of energy supply systems requiring government budgetary subsidy;

e. nurture the strengthening of domestic technological capability and capacity, particularly in support of the development of energy industry, that include the manufacturing of energy devices.

There does not seem to be any problem in satisfying the above criteria by taking co-generation system as an investment theme. In fact, investments in engineering firms to undertake co-gen system design and device manufacturing, and for implementing co-gen systems in various sectors (industry, commercial and services, and the power generation) will all lead to the achievements of the objectives implicitly and explicitly expressed in the above criteria.

In terms of economic feasibility and attractiveness, while the general policy on energy is clearly supportive, there still need to be changes to current policy on capital investment financing, taxation, import duties and most important of all, energy pricing. Except for energy pricing the government will be perceptive for such policy changes, since 1983 the government has been taking continuous actions to direct the economy of the country to be more efficient, and is still continuing to do so.

An important element to set such drive for policy changes, however, is still required There has to be a thorough and convincing analysis that indicate the benefits of making the desired policy and regulatory changes that would, among others, promote energy conservation in general, and the functioning of co-gen systems in particular The results must be followed-up by information disseminative activities, presenting technical and techno-economical aspects of co-gen systems These are directed to the business community.

Since the government is the main object of the 'advocacy' for policy changes, the effort has to be undertaken by some entities having the necessary resources to do so. Some inputs from international funding agencies or other supportive agencies are required

Carefully designed demonstration projects in various applications through risk sharing scheme between the sponsoring agency and the recipient of the demonstrated system will enhance the appreciation of implementing co-gen system.

In summary, the parameters for the development of conducive environment for the wider functioning of co-gen systems are:

a. information dissemination through workshops, training, demonstration and analysis work that will create better understanding and appreciation about the technicalities and the economics of co-gen systems;

b. technical and engineering capability development in the operation, manufacturing and design of co-gen systems and devices through appropriate technology transfer channels and mechanisms, involving capable technical institutions and business enterprises.

c. regulatory measures to provide tax incentives for capital investment and import tariff facilities to business ventures that deliver goods and services for the functioning of energy conserving systems in general, and co-generation systems in general, and co-generation systems in particular.

d available financing facilities that are significantly supportive to investment in business ventures in the area of energy conserving efforts.

5. Conclusions and recommendations

The following conclusions can be drawn from this study:

a. In the energy development of the country, the rate of growth of electricity supply has been increasing at very high rates, yet there is sustained unmet demand. The current estimate is that for the coming years, the averaage demand growth rate for the period of 1994-1998 will be around 17% per annum, declining to 12% during 1999-2003, and in the following five year develoopment plan (2003-2008) may further decline to an average of 8% per annum Even though there is a declining trend in the projected demand growth rates, the figures are very high. Most of the power demand are concentrated in the island of Java.

b. Since oil and natural gas both play determining role as source of foreign exchange revenue and also because of declining reserves, the availability of oil and natural gas will be limited. The power sector is therefore anticipated to be dominated by coal based generation plants. Such high share of coal utilization, however, is presently considered to be environmentally undesirable, unless less polluting coal technology and mitigative techniques are utilized. This will require higher investment costs, while capital availability is highly constrained

c. Conservation measures is therefore essential to be pursued, and there is considerable potential for that. The present total loss is still relatively high, i.e. within the range of 23-26%. Furthermore demand side management has not been practiced Efficiency improvement of the

power sector is also desired in terms of fuel conservation and from environmental point of view.

d. As one of the many means of achieving improved efficiency, this study has focused on the potentials of wider application of co-generation technology. While the technology is not completely unknown in the country, it is observed that there is considerable degree of lack of familiarity and appreciation.

e. An initial analysis of the opportunity for augmenting co-generation to existing power generating systems in the industrial, commercial, and power sectors indicates that there is around 4900 mW potential capacity for co-generation. This would be equivalent to an additional power supply of about 1600 mW installed capacity, if the recovered waste heat were used in a combined cycle mode of operation

f The observation pointed out in points (d) and (e) implies that there is a need for technology transfer processes to be undertaken, and there is economic justification and feasibility for undertaking the transfer process through investment channels.

g. Assessing the domestic capability and capacity in engineering design and equipment manufacturing, the study suggests that the transfer process is best undertaken by focusing first on the development of co-gen systems design capability, and the manufacturing of the stationary components of the co-gen system, such as efficient heat exchangers and waste-heat boilers The manufacturing of rotating equipments can be considered at later stages Until such undertaking is considered justifiable, rotating equipments and instrumentation devices are components that have to be imported. It must be noted that the requirement for rotating equipment arises only when a combined cycle system is to be delivered.

h Finally, it must be pointed out that some advocacy initiatives is necessary to develop more conducive environment for the wider funtioning of co-gen systems, whereby the support of donor agencies may considerably help in accelerating such effort.

On the basis of the above conclusions, particularly points (e), (f), (g) and (h), it is recommended that further study be made, focussing on the assessment of the market-potentials for implementing co-gen systems, and based on that produce a set of proposed investment schemes for the realization of commercially operated co-gen delivery systems and the commercial application of co-gen systems, based on externally acquired best available technology.

Furthermore, considering that similar potentials are found in many Asian countries, it is also recommended that parallel with the previously recommended effort, mobilization of some funding resources be made to support the organization of a regionwide workshop and seminars, focusing on the technical and techno-economic aspects of the technology.

COUNTRY POLICY AFFECTING TECHNOLOGY TRANSFER IN IRAN

We gratefully acknowledge the generous support provided by Dr. Mohammad Sarir of Institute for Political and International Studies and Dr. Mahmoud Shriat of the Faculty of Health and Environment, University of Tehran, Iran, for completing this paper

1. Introduction

Considering the fact that emission of the most important gas in the Green House Effect, Carbon Dioxide, is unavoidable due to the use of Fossil Fuels, the best way of reducing this gas may lie in a more efficient use of energy on one side and increase in consumption of CO_2 on the other. In this respect, it was decided in the Bellagio Conference in April 1992 that every country should study one or more technological methods to reduce Green House Gases.

The Iranian study was suggested to be on,

1) Lighting
2) Afforestation and land use change

It was decided to discuss the problem of Afforestation and lighting which the Government officials are presently more concerned about. And, as mentioned before, this will reduce the consumption of fossil fuels and the use of more Carbon Dioxide.

2. Lighting

The demand for electricity has been growing due to the increase in population and use of electricity per head. In this respect the electricity generation is planned to reach 28 thousand Mega Watt during the First and Second Five Year Plan which is an addition of 17 Mega Watt to the present capacity of electric generation in Iran.

Considering the present efficiency of the power generation units, this will consume 50 thousand Mega Watt of heat energy with 33 million tons consumption of carbon in the form of CO_2 emission. In addition to that heavy consumption of fuels the cost of electricity is to be considered. At present, the Iranian Government is subsidizing 30 Rials for each Killowatt hour. Therefore, it should consider economic aspects of electricity generation which has to be produced with minimum cost and maximum benefit. For this goal, different technical and managerial methods have been studied. The summary of suggestion and theories will be outlined.

2.1 Reduction in the loss of energy in consumption equipment

Lighting is the main component of electrical consumption in Iran and more efficient use can play an important role in improving electric industry. With present technological advance a variety of bell-shaped electric lamps has been developed which are similar to florescent lights with a difference that by concentrating the electric circuit, it could be replaced with the traditional lamps.

Considering the efficiency of these bulbs compared to the traditional ones, they could improve the quality of the network. But its high cost and its economic aspects must be studied.

Saving in each Megawatt is equal to 0.7 MTOE. Saving in each MTOE is equivalent to 0.66 Million Tons of Carbon (in the form of CO_2).

If we reduce the energy used for lighting by 30%, the reduction in use of fossil fuels will be 27% which results in 7.7 million tones less carbon in the air.

For this programme we do not need new laws or specific actions. All that is required is a government decision to use this technology and determine the appropriate budget to subsidize the purchase of these bulbs. Government decision for the use of this technology and for the appropriate budget to subsiding the purchase of these bulbs will be sufficient.

concentrating the electric circuit, it could be replaced with the traditional lamps.

Considering the efficiency of these bulbs compared to the traditional ones, they could improve the quality of the network. But its high cost and its economic aspects must be studied.

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The only difficulty is the replacement of the existing bulbs with the new ones considering their prices with respect to their life span compared to the traditional bulbs.

The reduction in consumption which will lower the amount of investment needed for electricity generation will justify subsidizing the price of the bulbs to the consumer.

It has been forecasted that the power generation will reach 22500 Mega Watt by 1993, and 35000 Mega Watt by 1998. But due to difficulties, it does not seem that all the projects will finish on time. Presently, a generation of 5000 Mega Watt productivity is under construction, and hopefully, will be added to the network on time.

3. Electric industry in Iran

3.1 Past, present and future

The capacity of the power generation units reached 14000 Mega Watts in 1988 which had a growth of 6.5% between 1979 and 1988. The status of the power generation units controlled by the Ministry of Energy are shown in Table 1.

Table 1: Electricity Generation Situation in Iran between 1979-1989

Year/ Subject	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Maximum Consumption need (Mw)	3744	4390	4269	*	5704	6605	7370	7746	8289	8298	8985
Maximum assigned load (Mw)	3621	4143	4229	4923	5582	6333	6606	7464	7743	7762	8911
Operated power cut off (Mw)	123	247	40	*	122	272	764	282	546	536	75 **
Needed Energy (Million Kh)	*	*	22644	26407	30813	34568	37722	40385	43577	*	*
Energy supplied (Million Kh)	19441	19880	22406	26333	30509	34094	36720	39045	42554	43775	39956

* Reliable information not available

** Actual cut off in this year had been 1153 MW

These units are mostly using fossil fuels, and therefore, the Ministry is the largest consumer of the fossil fuels, and it is responsible for the largest emission of Green House gases (Table 2 shows the consumption of different fuels).

Table 2: Use of fuels in power plants under Management of the Ministry of Energy from 1979 to 1989

Year/Fuel	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Gas oil (Million L)	1398	983	948	1010	1289	1622	2191	1642	1480	1517	1259
Residual oil (Million L)	1064	1473	1900	1947	2618	3183	3568	4150	3559	3839	4100
Natural gas (Million M^3)	2335	2278	2360	3177	3621	3885	3993	3856	5451	5730	6863

Generation and transmission of electric energy has been expanding regardless of its costly operation.

Among the factors that have contributed to the failures which the Ministry of Energy has met by the growing demand for electricity are:

1. Rapid growth
2. Financial constrains due to dependence on foreign technology which requires large sums of foreign exchange allocations.
3. The low profit

4. Inability to secure fuels on time for the power generation unite which prevented the fuel use of these units in the network.
5. Other difficulties such as:
   - Social conditions
   - decentralization of decision-making
   - climate conditions of the country

4. Forests

Jungles in Iran are situated in the two distinguished Regions of North and West.

1. Forest in the north cover 1.9 million acres, from which 1.3 Million acres are considered to be devoted to Industrial purposes (worthwhile and ready for industrial activities) and the rest, 0.6 Million acres are semi-demolished forests.
2. Forests in the west cover 3.5 Million acres. Most of them are considered to be semi-demolished.

Every year two million cubic meters of wood is manufactured from these above mentioned jungles. Another 2 Mm^3 is also prepared by cultivation of woody trees and from gardens. Since the total need of the country for manufactured wood is 8 million cubic meter, there is a 50% shortage.

The FAO has estimated the per capita need of manufactured wood for people of developing countries to be 0.4 m^3. According to this estimation, the need of Iran should be 22 Mm^3 of wood. Obviously there is a far distance between the actual need and estimated figure.

General goal of the forestry in Iran are as follows:

A. Protecting the forests
B. Reviving the forests
C. Proper utilization
D. Relative self sufficiency in providing wood products

In the past 30 years, forestry plans for 630000 hectares and forest plantation of 52000 hectares in the North in addition to 2900 hectares in other areas have been implemented; this has compensated for a small propagation of the damage to the forests.

The following steps are to be considered with respect to the renewing the forests:

1. Planting 50000 hectares of forests in the North to revive the 600000 hectares of destroyed forest in this region.
2. Planting 50000 hectares of forests in the Western region to replace 3.5 million hectares of forest destroyed there.
3. Planting 11000 hectares of forest in other parts to provide wood.

The Budget for reviving the forests are as follows:

Planting forests	29000	Million Rials
Foresting	8366	" "
Forest engineering	5590	" "

The main causes of vegetation destruction in Iran are:

1. Movement of sand in the areas with a high speed of wind
2. Loss of pastures due to uncontrolled grazing specially with respect to goat.
3. Illegal use of forests and using the land for other agricultural purposes.
4. Wrong approach to the utilization of water leading to the lowering of the underground water level, and consequently to forest dryness.
5. Uncontrolled expansion of dry farming.
6. Natural, regional and industrial causes.

5. Transfer of technology

Transfer of technology in this report could be outlined into four parts: Development, Adaptation, Absorption and Acquisition.

Iran has considerable experience with respect to forest plantation and creation of forests with the help of irrigation. For many years Iran has developed forests around big cities such as Tehran, and planted special plants around deserts to stop the movement of sand and add to the green areas. In these respects, there will be no need for transfer of technology, and what is required is more educational centers for teaching forest plantation and natural resource engineering in order to train the required human resources for the projects. Other countries could also benefit from Iran's experience in these fields. What is needed for absorption, adaptation and development of technology in the research in the types of vegetation adoptable to the Iranian climate conditions, or the improvement of the local vegetation.

What is noticed with respect to forest plantation and reviving is financial assistance from international foreign sources such as World Bank and private

sector. Iranian Ministry of Agriculture, Ministry of Natural Resources and Jahad have extensive plans for the development of forests in the country.

The most important task and the relevant legislations that must be pursued are as follows:

1. Establishment of appropriate and adequate structure for the projects with the help of legislations in the parliament.
2. Establishing a balance between cattle pasture by purchasing excess cattle.
3. Executing programme in the development of pasture projects.
4. Executing programmes for reviving the pastures land to achieve additional potential for production of wood.
5. Coordination for the creation of balance among cattle, animal feed and pesture land.
6. Executing programmes for the expansion of animal feedssand other similar feeds in the country, and planting industrial trees.

JAPAN'S TECHNOLOGY TRANSFER POLICY AND PROBLEMS IN FUTURE

We gratefully acknowledge the generous support provided by Mr. Takao Tomitate of The Institute of Energy Economics, Japan, for completing this paper

1. Japan's official development assistance and technical cooperation

Japan's actual extension of Official Development Assistance (ODA) in 1991 reached $10,951 million, according to a million registered in 1990. This was the largest amount among DAC (Development Assistance Committee) member countries, followed by $9,642 million donated by the U.S. and $6,769 million by Germany. Japan's ODA included technical cooperation, which rose from $1,645 million in 1990 to $1,868 million in 1991, a 16.9% increase.

Although Japan's ODA tops the world in gross volume, it represents a mere 0.32% of GNP -- Slightly lower than the twenty DAC member countries' average of 0.34% and ranking 12th Given the rising expectations and requests by the rest of the world for Japan's assistance with the emergence of global environmental problems, Japan is being urged to increase the ratio of its ODA vis-a-vis GNP in the future By way of comparison, the U.S.'s ODA represents only 0.17% of GNP -- 20th place -- and Germany's ODA represents 0.4% of GNP -- 9th place. It is the major ODA donors' common obligation, therefore, to raise the ODA-GNP ratio.

Outlined below is the current status of Japan's technology transfer policy, centering on its technical cooperation, and an analysis of problems related thereto in the future.

2. General description of current status of Japan's technical cooperation

Japan is carrying out technical cooperation in various forms, as outlined below. There is project-type technical cooperation, which combines the acceptance of trainees, the dispatch of experts, and the provision of equipment. Other formats include development studies and the dispatch of Japan Overseas Cooperation Volunteers. Technical cooperation activities supported by public funds include the acceptance of students from the developing countries at government expense, and survey and research programs conducted by government-affiliated agencies and other organizations in cooperation with government agencies in the developing countries.

As is the case for total ODA, Japan allocates a large share of its technical assistance to Asia. A regional analysis of technical assistance

provided in 1990 shows that Asia received 49.08, Latin America 12.1%, Africa 7.6%, the Middle East 5.8% the Pacific 1.9%, and Europe 1.0%.

The current status of technical cooperation by major program is mentioned below.

2.1 Technical training program

Japan launched the technical training program in fiscal 1954 and received a cumulative total of 82,553 participants in the program by the end of March 1991. Japan received 5,183 participants in fiscal 1990. The technical training program includes group training, individual training, third-country training, the establishment and operation of training centers. In addition, Japan is providing "follow-up service for ex-participants," sending abroad 13 teams of experts to acquaint ex-participants with new technology and to give technical advice adapted to local conditions.

2.2 Expert dispatch program

Japan dispatched a total of 14,501 technical experts to overseas during the period fiscal 1955-1990, sending 1,592 experts in fiscal 1990. This program covers joint study projects, aimed at contributing to socio-economic development of recipient countries, dispatch of private-sector skilled workers and sending of survey teams.

2.3 Provision of equipment

Japan's provision of equipment necessary for promotion of technical cooperation began in fiscal 1964, having reached a cumulative total of ¥21 billion by fiscal 1990. In fiscal 1990, equipment worth ¥7,000 million was provided to 50 countries.

2.4 Project type technical cooperation

Project-type technical cooperation is a type of program whereby three forms of cooperation are combined into one· training of overseas participants, dispatch of experts, and provision of equipment.

Project-type technical cooperation implemented in fiscal 1990 involved 185 projects, including those completed within the fiscal year. Of these, 57 were social development cooperation, 35 were health and medical cooperation, 8 were population and family planning cooperation, 66 were agriculture, forestry, and fisheries cooperation, and 19 were in industrial development cooperation. By region, 106 were carried out in Asia, 17 in the Middle East, 18 in Africa, 41 in Latin America, two in Oceania, and one in Europe.

2.5 Development studies

Development Study is the general term that involves the following activities carried out for public development planning, which is necessary for the socio-economic progress of developing countries: i) organizing study teams composed of experts to contribute to the implementation of a development plan for the recipient country; ii) carrying out a field survey, as well as analysis and study in Japan of the findings of the field survey; iii) making a study report which serves as basic information on a socio-economic development strategy for the recipient country; and iv) promoting technical transfer in terms of study methods and a planning approach to local counterparts in the course of the development study.

Development studies are classified into the following categories; Master Plan Studies, Feasibility Studies, Detailed Design Studies, and Studies for Improving Project Efficiency.

In fiscal 1990, 275 development studies were carried out -- 182 development studies were funded from the budgetary item for development studies, 74 from that of overseas development planning studies, and 19 from that of resource development cooperation basic studies; 152 development studies were conducted in Asia, 25 in the Middle East, 35 in Africa, 54 in Latin America, 5 in Oceania and 4 in Europe.

3. Energy cooperation

3.1 Current status of cooperation in energy sector

<u>Bilateral ODA in Energy Sector</u>

(Commitment Basis)

FY	Grant aid (100 Million Yen)	ODA Loans (100 Million Yen)	Trainees accepted	Experts dispatched	J.O.C.V.
1986	56.09 (5.4)	1,120.78 (20.0)	155 (2.6)	22 (1.1)	0 (0.0)
1987	28.09 (2.6)	1,873.94 (26.9)	186 (2.9)	18 (0.8)	5 (0.6)
1988	28.91 (3.0)	1,564.23 (14.7)	196 (2.9)	49 (2.0)	2 (0.6)
1989	45.52 (4.3)	1,518.99 (15.5)	238 (3.2)	33 (1.4)	2 (0.2)
1990	9.63 (1.0)	1,057.83 (10.5)	211 (2.8)	22 (0.9)	0 (0.0)

Note:Figures in parentheses are respective shares in general grant aid (excl. grant aid for debt relief, non-profit grant assistance & small-scale grant assistance), ODA loans (excl. reschedule) and technical cooperation

(A) Compared with other advanced countries, Japan devotes a high proportion of its ODA to the energy sector. Over the past five years (FY 1986-1990) this area has accounted for approximately 15% of total financial assistance (E/N basis).

However, an analysis of past trends shows that assistance in this field has declined from the FY 1983 peak of ¥230.9 billion (32.6 % of total assistance). In FY 1989 and FY 1990 the energy sector accounted for only about 12% of total financial assistance.

This strong emphasis on energy reflects Japan's active cooperation in this field, which it regards as one of the most important areas of assistance because of the importance of energy development to the achievement of industrial development.

(B) Projects in energy sector have the potential to produce profits. For this reason, financial assistance is provided primarily in the form of loans

Over the past five years, loans have accounted for 98% of total financial assistance in this area.

In the case of Indonesia, for example, Japan has provided loan aid for such projects as a hydroelectric power station on the Brantas River in Eastern Java, and thermal power stations at Gresik and Surabaya. The power generation capacity created through this assistance now accounts for 31% of Indonesia's total capacity, and Japan's cooperation in this area has made a major contribution to Indonesia's economic and social development.

In Laos, Japan provided loan aid for a hydroelectric scheme, the Nam-Gum Dam. The output of this scheme is so large that Laos is able to earn foreign currency by supplying some of the electric power to Thailand.

(C) Cooperation in the field of energy involves such areas as energy resource development, power generation and transmission facilities, regional electrification, the development of new energy forms, energy conservation, and energy administration. Electric power generation projects are by far the largest category, but in recent years there has also been an increase in the number of regional and rural electrification projects.

3.2 Priorities for cooperation in energy sector

(A) Integration of Economic Planning and Energy Planning

It is important to incorporate energy planning into the economic plans of developing countries, and to provide assistance in ways that reflect medium and long-range policies relating to energy supply and demand and the development of energy.

When formulating energy plans, it is first necessary to prepare development and utilization plans that permit the achievement of the optimal energy mix, taking into account such factors as the extent of energy resources, geographical conditions, the structure of industry, economic growth rates, energy demand patterns, and population distribution.

Cooperation at the "software" level, including human resource development, the improvement of administration capabilities, and the establishment of the necessary legislation, is effective in relation to the drafting of these plans, and in this sense it will be necessary to enhance Japan's response at the level of technical cooperation.

Human resource development and technology transfers are also vital to the operation and maintenance of energy facilities, as well as to the collection and analysis of energy related data. Technical cooperation is also vital from this viewpoint.

(B) Correcting Imbalances between Urban and Rural Sectors

Rural electrification leads to improvements in rural living standards and is therefore vital to the elimination of gaps between the urban and rural sectors. However, there are a number of problems, including the limited profitability of electric power services in the rural sector of developing countries, and the fact that small-scale power generation for rural and regional electrification is more costly than large-scale generation. For this reason, assistance for rural and regional electrification should be provided primarily through grant aid.

Rural communities in developing countries are trees cut from nearby forests to provide domestic fuel in the form of firewood and charcoal. As a consequence of population growth many areas, such as Nepal and the Sahel region of Sub-Saharan Africa, now face serious fuel shortages and environmental problems due to the depletion of forests through excessive logging. In addition to small-scale power generation mentioned above, other approaches should also be considered, including the use of alternative energy resources such as dung, straw, and briquettes, and the popularization of efficient ovens.

(C) Environmental Considerations

Gases emitted by hydrocarbonate thermal power stations cause atmospheric pollution, much of which can be prevented through the improvement of plant management technology and the use of desulfurization and dust collection systems Japan possesses advanced technology in the field of pollution control and will need to make an active contribution through technical cooperation in this area. Since the high cost of these facilities would impose a considerable burden on developing countries, it will probably be most effective to cooperate in the development of simplified systems that suit conditions in recipient countries.

(D) Joint Financing with the Private Sector

Many developing countries have difficulties in developing their energy resources efficiently because of their limited financial resources for investment

in the energy sector. Some large-scale electric power projects cannot be financed solely through ODA, and consideration should therefore be given to the promotion of joint financing with private sector investors in cases in which the prospects for the recovery of funds are good.

4. Measures to be taken to implement Japan's technology transfer policy

4.1 Comprehensive and Integrated Structure of Technology Transfer

Outlined above is the current status of Japan's technology transfer policy, focussing attention on the government supported technical cooperation. The technical cooperation is comprehensive and integrated in its structure.

Let's consider technology transfer of, for example, a most advanced 600-1,000 MW coal-fired power generation plant (having a thermal efficiency of 39%), with highly efficient flue gas desulfurization equipment.

First of all, it is necessary to consider the transfer of technology for assembling and installing a generator and related facilities. (Transfer of technology related to production of these equipment and facilities is not considered here) Next, the transfer of the related technical know-how to management, technical personnel and laborers is undertaken, assuming that all of them are available to manage, operate and carry out maintenance of the power plant in question Then, supply of fuel and spare parts for maintenance must be secured. Moreover, an efficient network must be established for transmission, sales and distribution of the electric power that is generated. It is necessary that the project in question be well incorporated in power generation plans as well as energy plans of the state and regional area concerned. Of course, it is essential that adequate funds necessary to implement the technology transfer and technical experts to be dispatched from the donor country to recipient countries be fully available.

The technology transfer through establishment of a joint venture company is being carried out fairly smoothly in the area where these conditions are met, since the project is placed on a commercial basis Generally speaking, however, the larger the project becomes in its scale, the greater support by both governments in the form of preferential measures is needed in order to place the project on a paying basis. If the construction and management of the coal-fired power plant referred to above, for example, is implemented under the

"BOT" (build, operation, transfer) formula, in which developing countries are showing keen interest, the foregoing conditions must all be met. At the same time difficult problems such as establishment of power rate, assurance of the profitability of the project, and repayment terms for borrowed foreign capital must be resolved. Government support through powerful preferential measures is indispensable to successful implementation of the technology transfer, but there must be some limitations to this governmental support. It should be pointed out that, in the end, recipient countries' self-help effort is the trump card.

4.2 Establishment of priority order and importance of project finding

In order to successfully promote technology transfer, which is beset with a number of problems as outlined above, it is essential to establish an order of priorities and find a most appropriate project. In establishing an order of priorities for projects, it is important to pay due consideration to the following

1) Top priority should be given to technology that best fits the current conditions of recipient countries (especially the socio-economic realities and the people's lifestyles).
2) Technology that meets the foregoing conditions and has a high cost-effect.
3) Technology that can offer multipurpose solutions to serious problems now facing developing countries such as the gap in economic development between urban and rural areas, damage to forests, traffic congestion air pollution, trade deficits, and so forth
4) Given the above conditions, state-of-the-art technology is not necessarily essential; it is more important to find a project of transferring technology which may be at the infant or intermediate level and yet has a high cost-effect and is simple and low-cost
5) In more concrete terms, truly needed projects cover a wide variety ranging from "konro" (a portable cooking stove), "kamado" (an oven), improvement in thermal efficiency of boilers in a small-scale factory, coal washing, electric dust collector, to technologies of simplified desulfurization and fludized bed combustion, which help reduce air pollution and conserve energy - technologies which indirectly reduce CO2 emissions to a great extent

4.3 Measures for overcoming problems in Japan

1) Drastic expansion of energy and environment related ODA budgets and flexible appropriations thereof, governmental support of R&D studies in Japan of technologies suitable for developing countries and preferential measures applied to capital investments by joint venture companies in desulfurization and energy-conservation facilities.
2) Re-examination of the current formula of Japan's accepting requests from recipient countries, strengthened project-finding activities and expansion of research and bilateral/multilateral meetings.
3) Rapid expansion of training programs for recipient countries' technical experts. Expansion of the number of Japanese experts dispatched to recipient countries and education of talented personnel to provide such experts, and improvement in their salaries. Efforts to eliminate language barriers of those who are engaged in these activities. (In general, utmost efforts must be made to overcome the absolute shortage of human resources undertaking Japan's technology transfer.)
4) Promotion of cooperation to formulate energy master plans and plans for technology transfer which provide a basis for successful technology transfer

4.4 Measures for overcoming problems in recipient countries

1) Formulation of pertinent, realistic and detailed energy plans and technology transfer plans which are commensurate with economic plans and establishment of a system for implementation and management of those plans. Expansion of the data and statistics to support these plans.
2) Education of technical personnel undertaking the technology transfer and its maintenance, and efforts to produce related equipment/facilities and spare parts in recipient countries themselves.
3) Establishment of the "road to sustainable development" which best fits the recipient countries' culture and climate, and proposals for technology transfer plans commensurate with their culture and climate and measures to implement them.
4) Expansion of the government's preferential measures for technology transfers from foreign countries, including joint venture companies.

5. Conclusion

The technology transfer is a joint project between donors and recipients aiming at global "sustainable development" and common benefit. To make it a success, it is essential that comprehensive and integrated structure involving various conditions outlined above be firmly established, or at least that both parties spare no efforts to establish that structure. Otherwise, even if Japan increases energy and environment-related budgets, for example, actual projects will not be implemented in an appropriate manner - a situation distressing to both parties.

STUDY ON ROLE OF TECHNOLOGY TRANSFER IN ABATING GREEN HOUSE GAS EMISSIONS: THE CASE OF SRI LANKA

We gratefully acknowledge the generous support provided by Mr. K. Gnanalingam of Ceylon Electricity Board and Dr. Tilak Siyambalapitiya of Sri Lanka Energy Managers Association, Colombo, Sri Lanka for completing this paper

1. Introduction

1.1 The energy scenario

In Sri Lanka 6.6 million tones of oil equivalent of total energy was supplied in 1989. The share of commercial energy was 1.9 million tones of oil equivalent or 29 per cent. The balance 71 per cent was from fuel wood. Central consumption of commercial energy in 1989 divides into transport 55%, house hold 20%, industry 18%, agriculture 2% and others 4%.

Hydro remains the major source of electricity supplying about 3,000 GWH in 1990. Thermal generation account for about 5% only. Impact associated with the generation of hydro power is linked to the construction of dams and reservoirs. No major impact can be expected from the thermal source at present, in view of its limited use.

But environmental safeguards will be required when thermal plants are continuously operated or when new plants are planned. It is evident that transportation sector is the largest consumer of commercial energy. The principle environmental impact associated with transportation is air pollution.

National Environmental (amendment) act of 1980 gives the Central Environmental Authority (CEA) among other powers, the functions; the control emissions, disposal of wastes into the environment and to subject development activities to environmental impact assessment at project planning stage.

The former has been given operational effect through the National Environmental (Protection and quality) Regulation No 1 of 1990).

1.2 Prevalent policies in the country that affects the process of technology transfer

The Board of Investment (BOI) of Sri Lanka has been created recently. The BOI is the sole authority for promoting and approving investment in Sri Lanka. It functions as the "One Stop Shop" service centre catering to every need of the investor. It administers three Free Trade Zones established for investors. In addition, an attractive package of incentives is offered for export oriented investments. Approval procedures have been evolved, shorn of bureaucratic delays, to the point where it has become simple and transparent.

An attractive package of incentives with no restrictions on repatriation of funds and dividends and tax holidays up to 15 years and more have been introduced. The other significant developments are:

- Liberalised policies of import/export.
- A well developed infrastructure and BOI's experience of over 14 years in the operation of Export Processing Zones.
- The high literacy of the workforce.
- Simplified approval procedures.
- Free operation of foreign Bank Accounts.

100% foreign ownership or joint ventures with local investors.

The primary objective is to attract foreign investors and provide them with maximum opportunities for investment, trade and joint ventures. Arrange one-to-one meetings and visits to the Export Processing Zones. And appraise them of the areas of foreign investment.

It is our view that Sri Lanka has so far no restrictions as far as the process of technology transfer. It is open for any type of technology provided the industries that are set out will promote the use of unemployed human resources of the country instead of making use of machines and reduce labour content.

2. Historical perspective : since 1982

In 1982 Dr. Mohan Munasinghe from the World Bank was on an assignment as energy advisor to the President of Sri Lanka for a two year period. He initiated an Integrated Energy Planning system so that inter Ministerial coordination takes place in all energy related matters. The Ministry of Power and Energy was created and the National Planning took important details from Ministry of Forestry, Transport, Power and Petroleum sectors. Unfortunately, force task for which were created has been dispensed with and action has to be taken to revive them.

Present Government intention: regarding energy conservation is shown by the creation of the State Ministry of Conservation from the year 1991. We are glad to note that Director of this Ministry of Conservation is the past President of S.L.E.M.A. It is expected Government will be able to give more incentives for energy conservation matters.

Parts of Energy Conservation Fund which is presently used for preparation documents to be issued to the public at exhibitions on conservation. Regular T.V. and Radio programs are held under the auspices of this ministry.

In the **domestic sector** following conservation measures are under consideration.

For cooking improved cook stove are being promoted through the Ministry of Power and Energy. Use of gas in preference to electricity is being promoted by pricing. Use of good conducting bottom vessels in cookers, use of rice cooker which are fully insulated, use of pressure cookers which reduce energy consumption are all being promoted.

Efficient lighting: A separate report on the use of efficient lights is annexed to this report. It is estimated that about 80 megawatt (1/10 of Peak) of power is caused by smoothing Irons which is being used by all the houses daily. An effective change to material of Non-Iron type could save this load and it also reduces the energy use.

Action is being taken to work with Institute of Architecture in planning and designing houses so that they will use natural lighting. Wherever air-conditioning is used the house has to be designed to minimize losses and to prevent direct solar radiation into the house.

Domestic solar water heaters had to be promoted by giving tax incentives.

At present energy management is used in the industry and almost all large industries have efficacy engineer or a Energy Manager in their staff. A good part of the industrial load comes from hotel industry. Regular seminars and training of boiler operators are held annually to promote this energy conservation activity by SLEMA itself with support from Ministry.

In **agriculture** four wheel tractors and two wheel tractors have been introduced in the recent past.

Research institutes studies indicate that the energy used by four wheel tractors for ploughing is inefficient. Deep plugging is not really required. A two wheel tractor may be a better compromise. Solar powered battery weed cutting device and ploughing machines are being proposed by the agricultural research institutes. The sea around Sri Lanka is intensively tapped for fish. Energy efficient boats need to be introduced for this activity and energy efficient. Refrigeration need is high in the processing of fish.

Several steps have been taken to improve viability of **public sector** industries. Opening up opportunities to engage in joint ventures with large foreign companies is one of them. Collaboration with Japan, Germany,

Australia, Britain are some examples. A presidential commission on privatisation has completed a study on 21 public enterprise with World Bank assistance. It has categorized enterprise into three those that had to be closed, those which can be within a short period be restructured either financially or technically, those which have to be privatized.

The balanced development of energy planning skills both at management and technical level is important. Underlying theme should be self-reliance in energy planning, because the final responsibility of the integrated national energy planning should rest on local staff and policy makers. Although in many cases it may be necessary to rely on foreign experts or consultants to initiate the process and play an advisory role, the training of local counter parts and the goal of eventual transition to completely the national staffing should have a high priority. At the same time because both technical and economic knowledge in the energy area tends to change rapidly energy planners should have good up-to-date library and documentation facilities as well as ready access to international conferences training courses and meetings. Finally if salary levels are inadequate it will be rather difficult to recruit and retain personnel with energy related skills. It is our experience that large number of experienced professionals have left for greener pastures in other parts of the world, some taken away by the consultants or loan giving bodies.

2.1 Industrial policy

In 1990 initiative were taken with regard to the implementation of new industrial policy introduced by the Ministry of industries science and technology. The greater Colombo economic commission (GECE) and foreign investment advisory committee (FIAC) were merged in January 1990 to form a one window in order to facilitate entry of foreign investments. Approval procedure were also simplified. In response, foreign investment, in January 1990 foreigners were permitted to own 40 per cent of shares of existing companies without any approval. Multinational corporation are showing preference to investing in countries with the well educated and technically qualified work force. More sophisticated industrial production requires skilled labour. Therefore the availability and cost of skilled labour become very significant. Since we have the disadvantage of a small domestic market internal insecurity and perceived country risk, our ability to attract a higher

level of foreign investment would depend on the development of our infrastructure and improvement in the quality of our labour.

New industrial strategy was introduced in 1990 by Ministry of Industries with a view to restructure the overall domestic Industrial Policy. It intends (a) Transform the import substituting industry to an export oriented industry (b) Provide greater employment and income opportunities. (c) diversify the economy and strengthen the balance of payments and (d) ensure more equitable distribution of income and wealth.

The strategy also includes policy measures aimed at mobilizing resources for investment and export; encouraging foreign and local investment; reforming public enterprises; promoting a competitive environment; establishing linkages between large and small industries; promoting research, training and marketing and removing administrative obstacles to investment, production and exports.

In promoting research, training large amount of work can be done for technology transfer and conservation.

2.2 Changes done in foreign investment policy in 1992

Changes in exchange control regulators to all foreigners and foreign agencies to fully buy up certain Sri Lankan ventures has been gazetted. Government will permit non nationals and approved foreign funds and corporate bodies to purchase shares in Sri Lankan companies up to 100% of the issued capital subject to certain restriction (If capital is more than one million US dollars).

The 100% transfer tax composed on transfer of assets between nationals and non-nationals also has been already abolished.

A textile mill which was a gift from East Germany in nineteen eighties was such a sick and efficient plant. For acquiring spares we had to lose a large amount of foreign exchange. Many energy management programmes were developed but when a Korean firm bought this up to Total Electrical Power requirement came down from 25-30 MW to 15 MW and they used only half the floor area for there machinery and production was doubled. No staff were retrenched at take over this being one condition of transfer. Technology transfer has improved efficiency reduced wastage. Some of the profits will leave the country.

2.3 Conclusion

Too much of forcing on a developing country to reduce emission of green house gases can be accepted only if the necessary funds for capital investments and the technology transfer for more energy conserving devices can come. Use of alternate source of energy be promoted.

Studies sponsored by USAID programme through TERI gives encouragement that there is a hope in the future for proper transfer of technology and funds will be available to reach the targets.

One also feels that it is best to learn to live in harmony with the nature than work against it then our life will be peaceful. Nature will definitely look after itself. We should try and disturb it to the minimum in reducing our wants.

3. Case study of energy efficient lighting systems in Sri Lanka

3.1 The background

Sri Lanka's national electricity grid provides all the electricity requirements in the country, except in a few very remote areas where, if at all, small generating sets are being used for a few hours of the day. The system demand profile given in figure 1 shows a very high peak during the evening hours of 1800 to 2000 hrs. The system load factor for 1991 was 56% which has been recently varying between 54% and 56%. Ceylon Electricity Board is optimistic of achieving a higher load factor of 58% by the year 1997.

Sri Lanka Power System is predominantly hydroelectric in which the entire demand as of now can be met from hydroelectricity in an average rainfall year. The poor load factor is not of significance when generating capacity is considered; the hydroelectric system has over 80% reserve margin. The sharp peak in the evening is only of significance now for the transmission and distribution system, and the substations in which certain links are overloaded during the peak. However, high reserve margins will not prevail for long as the generating system is presently transforming from a predominantly hydroelectric system to the a mixed hydro-thermal system. Any savings in peak time capacity requirements would certainly be beneficial from about the year 1998.

However, the sharp lighting peak in the evening causes a heavy demand for energy. It can be clearly identified that the evening peak demand is almost

entirely caused by household lighting; the street lighting and commercial buildings cause not more than 10% of the 300 MW evening lighting peak. With the rapid rural electrification programme of the government in which most new consumers are households, the system load factor and peak time energy consumption can only be expected to worsen.

The time-of-day tariff introduced 6 years ago is now available to medium and large industrial and commercial consumers as well as for hotels. This tariff carries unit charge of double the regular rate between 6 pm and 9 pm and rebate for energy used during off-peak hours. While the exact benefits of the time-of-day tariff for large consumers is yet to be evaluated, introduction of such a tariff for households has not been considered yet.

Therefore, the only alternative to achieve the desired improvement in the system load factor and to bring about a reduction in household consumption of electricity, will be to improve the efficiency of lighting system used in the households. This paper describes the efforts made so far towards this objective and their results, together with details of costs and benefits of a possible state sponsored or private sector funded popularization programme to popularize efficient lighting system.

3.2 The composition of the load curve

The electric system demand curve shows a sharp peak approximately between 6pm and 9pm on all days of the week. On a typical Weekday in February 1992 (see figure 1), the system demand increased from 380 MW at 6pm to a peak of 680 MW at 7.30 pm. Figure 1 shows the half-hourly peak but the instantaneous peak may be higher.

In the absence of a specific study at the consumer level on the composition of the demand curve, it would be reasonable to assume that the total evening lighting load in the country is 300 MW. If an allowance is made for the industries finishing their working shift at 6pm, this estimate can be higher. Similarly, an unknown portion of the evening peak would be taken up by television sets. With the exception of street lamps, the lighting load operates for about 3 hours a day. Therefore, the corresponding energy use will be 300 MW x 3 hrs x 365 days = 329 GWh/ year. There is also the day-time lighting load, especially in commercial buildings, which has not been estimated.

The mix of lamp types causing the lighting demand is also not known. An estimate may be made by assuming that at least 3 incandescent lamps of 40W each would be operated in each household at peak time, which amounts to an incandescent share of 120 MW in the evening demand from the 1 million households electrified. There is widespread belief that this share is higher, reaching at least 200 MW.

Owing to financial constraints, households newly electrified would always be on incandescent lamps. These will be partially replaced with fluorescent fittings depending on the level of the consumer's awareness on energy conservation potential and his ability to pay the higher costs required. The quality of conventional fluorescent fittings available in the Sri Lankan market is not satisfactory, with excessive losses occurring in the ballast. The fluorescent bulbs used in the fittings also do not generally provide the best luminous efficacy of the conventional bulbs.

The lamps used in the commercial buildings and in industries during all hours of the day are not estimated here because a proposed programme for popularization need not give incentives to such consumers. The exception will be public institutions such as hospitals and government offices, which remain under the direct control of the government.

3.3 Previous efforts

The efforts by the Government, state agencies and NGOs in the improvement of the efficiency of lighting systems began in the late 1970s with the national electric power utility, the CEB, conducting publicity on energy efficient lighting systems. However, the serious efforts for widespread use of fluorescent lamps began only in the mid 1980s with the sharp escalation of electricity tariffs.

It would be confidently expressed that large commercial buildings and hotels in Sri Lanka now use fluorescent lamps to the best of their ability and limit. The area that needs special concentration is therefore the household sector.

Households consume nearly 40% of the electricity consumed in the country, a significantly high share for any country. Industries consume yet another 40% and remainder is taken up by the hotels, commercial buildings and street lighting.

3.4 Regulatory measures

The major issues in the regulatory framework for energy efficient lighting systems are,

(a) the absence of efficacy standards for lamps locally manufactured and those imported into the country

(b) the poor enforcement of the quality standards

(c) the absence of national guidelines/standards for the levels and quality of illumination within buildings

(d) the taxes and duties applicable to lamps.

There is an established local industry for the manufacture of incandescent lamps together with Sri Lanka standards for covering their quality. However, the standards do not cover their luminous efficacy and overall energy efficiency. There is no local industry manufacturing fluorescent lamps for the local market (there is at least 1 export-oriented venture). Thus all such lamps and the accessories are imported. Fluorescent lamp assembly is done locally. The import of fluorescent lamps of poor luminous efficacy and quality (life expectancy etc), ballasts of unacceptable loss and audible noise levels, are widespread. Further, the assembled fittings do not consist of a power factor correction capacitor, which has an adverse effect on the consumers' and system power factor as well as on the luminous efficacy of the lamp. Existing standards do not cover the luminous output of lamps. Standards do not cover the energy efficiency of the ballast.

The enforcement of quality standards in terms of the electrical characteristics of the lamps and fittings requires to be strengthened. The initial requirement is to enforce the existing national standards on all locally manufactured and imported lamps, accessories and assemblies. The present practice is for the lamps and lamp fittings to carry the approval from the Standards Institution, if they confirm to the relevant Sri Lanka Standard. The majority of lamps and lamp fittings available in the market do not carry the approval of the Standards Institution.

The level of awareness among the general public, engineers and architects about appropriate illumination levels for different tasks, optimization of daylighting and the design of buildings for energy efficiency is low. An awareness campaign supported by informative material, seminars, training courses and an award scheme have been suggested by SLEMA and it is hoped

that the Sri Lanka Institute of Architects will participate in this campaign. A pre-requisite for such a programme would be the national standards/guidelines for efficient illumination systems for buildings.

The import customs duty for conventional fluorescent lamps is fixed at 5% of the value while the compact fluorescent lamps carry a 30% duty. An immediate priority action that can be taken by the Government is to totally abolish the duty of fluorescent lamps, both conventional and compact. This should allow the lowest possible cost of these lamps in the market. The cost of lamps are of importance, especially at a time when there is rapid depreciation of the value of Sri Lanka rupee against the US dollar and when there is high (over 10% per year) inflation in the country.

A further issue that requires detailed study and follow-up action is the electricity tariff structure. While the electricity tariffs structure in Sri Lanka is guided by long run marginal cost considerations, the low-consuming group upto 100 kWh/month receive electricity at a subsidized price as follows:-

Upto 10 kWh/month	at 0.55 SLRs/kWh
Next 40 kWh/month	at 1.05 SLRs/kWh
Next 50 kWh/month	at 2.00 SLRs/kWh
Next 350 kWh/month	at 3.00 SLRs/kWh
furhter use	at 4.00 SLRs/kWh

(Note.- Average price of electricity is 2.40 Rs/kWh)

Household electricity consumers using less than 100 kWh/month receive electricity at a subsidized price, well below the average selling price of 2.40 SLRs/kWh achieved in 1991 for the entire utility. (Note that the average tariff too does not exactly reflect the true cost of electricity but it can be used as an indicator of the finances required to retain the financial viability of the utility).

The majority of the household consumers consume below 100 kWh/month and hence they are subsidized (by the other electricity consumers). The important factor is that these very consumers who receive electricity at subsidized rates are those responsible for the high evening lighting peak and all the consequences thereby.

3.5 Replacement options

In formulating a programme for widespread used of energy efficient lamps, the following replacement options have to be considered:-

(a) Replacement of incandescent lamps with conventional fluorescent

(b) Replacement of conventional fluorescent lamps with high efficiency fluorescent lamps and fittings, including the use of compact fluorescent lamps.

(c) Replacement of incandescent lamps with high efficiency fluorescen fittings, including the use of compact fluorescent lamps.

The country has very little experience with the use of high efficiency fluorescent lamps, especially with compact fluorescent lamps (CFLs). Technical issues related to the operation of such lamps, with regard to the voltage and frequency effects, and how widespread those effects are in the existing system, requires further study. Views have been expressed as to whether a component system, where the ballast, starter and the high efficacy bulb are individually replaceable would be more suitable than a compact fitting.

3.6 Model for the popularization of efficient systems

The manner in which efficient lamps and fittings should be popularized further in the efforts to improve the efficiency of electricity use, thus reducing greenhouse gas emissions has been under discussion for some time. It has been recognized that widespread use of efficient lamps in the households would require financial assistance for the consumers to meet the initial cost of the lamps and fittings.

(a) A state sponsored programme

(i) An option for the State utility would be to distribute free compact fluorescent lamps to households, in an effort to strongly carry the message of their high efficacy. If a 40W incandescent is replaced with an 11W compact fluorescent, the 120MW demand estimated in the earlier section would reduce to 33 MW and 95 GWh/year would be saved. Generating capacity is not a constraint in the Sri Lanka system as yet because the system carries a high reserve margin. The energy saved is valued at 228 million Rs/year (i.e. at 1991 average tariff of 2.40 Rs/kWh).

From the utility's point of view, the costs and benefits are as follows:-

Assuming consumers save their marginal units usually paid for at 1.05 Rs/kWh,

Present subsidy to household	=	131 GWh/year x (2.40 - 1.05) Rs/kWh
	=	177 million Rs/year
Subsidy after installation of CF lamps	=	36 GWh/year x (2.40 - 1.05) Rs/year
	=	49 million Rs/year
Subsidy saved	=	177 - 49 = 128 million Rs/year
Number of lamps required	=	3 million
Market price of a lamp	=	Rs 600
Total cost	=	3x600=1800 million Rs

Thus for an entirely utility sponsored programme, 1800 million Rs require to be invested, saving 128 million Rs/year of subsidy to households which makes such an investment unattractive to the utility, showing a payback period of 14 years. Duty free import of lamps too would cost about Rs 400 each and the payback period would then be 9 years. The reduction in peak demand requires to be shown to cause the cancellation of a new power station, in order to further justify such an investment. This issue will arise only after about the year 2000, when the system reserve margins are expected to fall to international norms of 20-30%. The 87 MW of peak demand reduced can be assumed to avoid the investment on a gas turbine with a capital cost of Rs 1914 million, which clearly indicates the viability of investing Rs 1200 million in a CFL programme at that time.

However, a free CFL distribution programme does not appear to be viable now for the utility, unless heavily supported by the Government and external funding agencies.

A further justification for the use of CFLs would be the reduction of greenhouse gas emissions, by the expected saving of 95 GWh/year, which under average hydrological conditions, would be marginal units generated from thermal sources. The thermal source presently earmarked to meet this demand are residual oil fired diesel engines.

(ii) A further option is for the lamps to be distributed on loan, to be recovered in instalments on an interest-free basis. Assume a household purchasing 3 x 11W lamps.

Cost of lamps	=	3 x 400 Rs = 1200 Rs
Energy saved	=	(40-11)W x 3 x 3 hrs/day x 365
	=	95 kWh
Cost saved	=	95 x 1.05 = 100 Rs/year
Consumer's payback period	=	12 years

The payback period is unacceptable to a consumer. However, the payback duration will change for consumers in the higher monthly consumption blocks, whose marginal kWh is paid for either at Rs 3 or 4 but such households are a small share of the total.

(iii)Options (i) and (ii) above clearly indicate that a CFL programme fully paid for by the utility or by the consumers would not be viable, under the present generating system configuration and the consumers' tariff structure. The lifeline rates for lower-income consumers are likely to remain for some time and the system load factor is likely to remain low as long as the greater emphasis in system expansion is placed on rural household electrification.

There are also the possible weaknesses in a state/utility-run implementation programme. The utility is continuously engaged in the expansion and rehabilitation of the distribution network and handling day-to-day consumer services. The time available for the regular field staff to provide and monitor the use of CFLs in the households would be limited.

(b) A private sector project to handle the popularization of CFL is another option but at the outset, it has to be clear that Government or donor funding should be made available to launch the project.

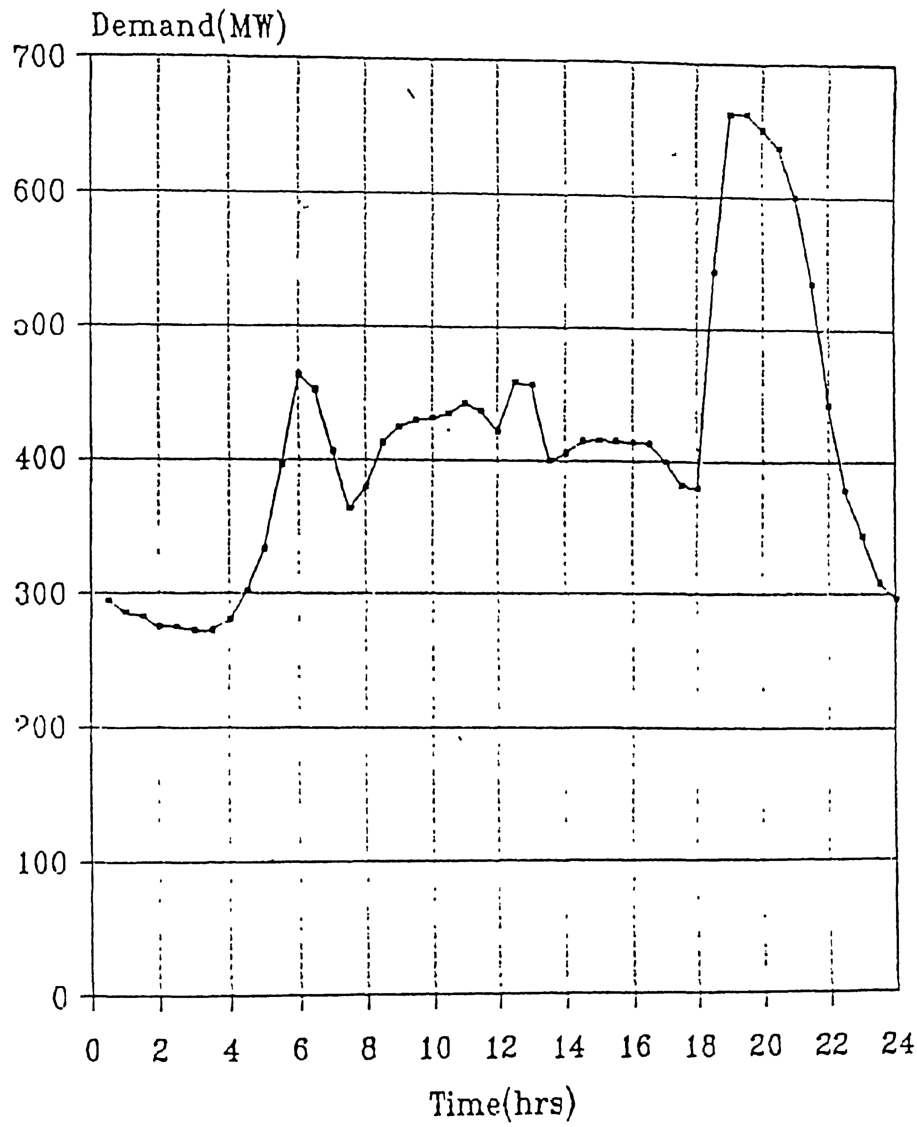
The subsidy may be arranged in terms of the number of bulbs sold, in which the consumer returns a confirmation note to the Government/utility about the receipt of the lamp. A private organization with a strong engineering and marketing background and its own dealer network would be better placed to promote the use of CFLs, provide field level support and monitor their use, than a state utility. Adequate safeguards have to be built-in to protect the investment of the state/donor in the project together with backup monitoring by the utility/donor.

3.7 Summary

The problems to be solved in the use of efficient lighting systems, with one of the objectives being the reduction of greenhouse gas emissions, are not strictly related to technology transfer but the dissemination of the technology already available. The barriers to overcome are the high capital cost and technical performance of efficient lighting systems on one hand and the subsidized household tariffs that make the critical component of system demand insensitive to the financial benefits of efficient lighting systems.

Figure 1

Sri Lanka Power System
Half-hourly Demand Profile at Generation
Wednesday, 12th Feb 1992



Not adjusted for disconnected
Northern load

AEI COLLABORATIVE STUDY ON ROLE OF TECHNOLOGY TRANSFER IN LIMITING CO_2 EMISSIONS: THAILAND'S COGENERATION AND ENERGY-EFFICIENT LIGHTING

We gratefully acknowledge the generous support provided by Dr. Charuay Boonyubol and Dr. Chaiya Chamchoy of Chulalongkorn University, Thailand for completing this paper

1. Introduction

As the results of the Collaborative Study to Limit CO_2 Emission in Phase I, the study recommended that the rate of greenhouse gas or GHG emission worldwide must be reduced. This may be achieved by a number of methodologies. The following methodologies are suggested.

(1) Energy conservation.

(2) Measures to reduce the rate of deforestation.

(3) Measures to discourage the use of wood from natural forest as fuel.

(4) Replant fast-growing trees for energy.

(5) Replace conventional fuels by renewables.

The first methodology suggested, i.e., energy conservation seems to be the most implementable methodology among others and in fact has been accepted widely as an efficient means to conserve energy

By energy conservation we mean using energy only when necessary and as efficiently as possible. Energy has been consumed by mankind for several thousand years for ways of living and comfort In the past 50 years, energy consumption by mankind has increased at a considerable sharp rate in transportation, industrial, business and residential sectors. Energy has been used in an inefficient and luxurious manner as a result of cheap oil, until 1973 when the first oil crisis occurred, followed by the second crisis in 1979. Oil prices had been sharply increased, creating concerns to governments of oil importing countries to reduce oil consumption by energy conservation measures and energy diversification.

Energy conservation measures have been adopted and successful in industrial countries Japan where energy supply is largely dependent on imported energy could be cited as one of the most successful countries in energy conservation. Energy efficiency has been increased and losses have been reduced. Research and development to switch to renewable energy such as solar and wind have been and are being carried out. Japan targets at its industry mainly and has been successful. It is to be noted that cogeneration of heat and power which was a practice in the industry about a century ago and was halted when cheap power from distribution lines was available everywhere, has revived with success in industrial countries during the last ten years after the second oil crisis. Unfortunately, cogeneration has not been so successful in

developing countries due to lack of government measures and incentives, and due to low economic growth and underdeveloped industry.

Energy conservation measures have been successful not only in increasing the energy utilization efficiency, but also resulted in reducing CO_2 emission rate. In Thailand, priority has been given to energy conservation in industry and buildings. Legislative measures were considered to be an effective instrument for energy conservation policy.

In the following context we shall discuss in general Thailand's policy in energy conservation that will affect technology transfer in two selected priorities, namely, industrial cogeneration and energy-efficient lighting for buildings.

2. Thailand's energy conservation policy and measures

Thailand is a net energy importing country Its dependence on imported energy, mainly petroleum, is about 45% of country's energy demand After the second oil crisis in 1979, Thailand suffered a major economic setback due to large expenditure on import of oil. Energy conservation has been a national policy to reduce Thailand's oil dependence since then. Public relation has always been put forward by governments as priority measures aimed at the general public. They set up ministerial level committee and use government mass media such as televisions, radios to urge the public to use energy efficiently in order to save energy for the young generation This has been a practice for years without success due to perhaps lack of knowledge about technology of energy conservation among top decision makers, or perhaps due to normal practice of elected government to use government mass media for their own sake in seeking popularity for next general election. The sole government energy agency, the former National Energy Administration now Department of Energy Affairs, had tried to convince past governments for almost six years to enact a law on energy conservation, but unfortunately they were not successful. The failure was due to perhaps not only the lack of seriousness on the part of politicians or lack of political will, but also to the fact that the content of the law proposed aimed to regulate and control the users of energy, particularly the industry and the owners of buildings, without positive measures or incentives to give assistance technically and financially to private sector.

During the interim period of the unelected Anand Punyarachun government in 1991, energy conservation was again stated as national policy. But this time the government took it seriously and used legislative measures as an instrument to put forward its policy into action. The Prime Minister utilized his National Energy Policy Office to revise the previously proposed energy conservation law. The content of the law has changed to provide incentives to private sector to conserve energy for their own benefit, which in turn will benefit the country in the long run. The government realizes that besides housekeeping and retrofitting measures for energy utilization efficiency, capital investment for new equipment of higher energy efficiency would be necessary for the industry. Therefore, energy conservation funds were stated in one section of the law as a commitment from the government to provide financial assistance to energy conservation projects The law was enacted within three months after the appointment of the working group for revision, in contrast with the six-year period of drafting the old version of the law. The energy conservation act was announced in the Royal Gazette in April 1992 and became effective since then, thanks to the Anand's government. It is believed that the newly enacted energy conservation act in conjunction with the current investment promotion act and government policy on energy conservation would affect the technology transfer as follows

2 1 Investment policy and tax incentives

Before the energy conservation act became effective in April 1992, the government has already had a policy to promote energy conservation by issuing a Finance Ministry Announcement to reduce import duty of all proven energy conservation machinery and equipment from about 40% to 10%. The process of approval of energy conservation projects is done through a special committee set up by the Department of Energy Affairs. The process has been slow and taken long time before a project could be approved. The energy conservation act through the energy conservation funds would provide an alternative incentive by giving financial assistance to approved energy conservation projects equivalent to tax incentive. It is believed that it would eventually replace the tax incentive measures by the Finance Ministry. The energy conservation Act provides incentives for investment in energy conservation equipment industry too.

2.2 Capital financing

At the moment there is no special financing arrangement for energy conservation project provided directly by the government. However, the energy conservation project would be equally eligible to receive capital financing with low interest rate from the government-owned Industrial Finance Corporation of Thailand (IFCT) as other government approved projects. Capital financing is not much a problem for large firms which normally have good relation with the banks. In the future, it is hoped that the government would consider capital financing to small and medium industries.

2.3 Energy conservation-related programs

One of the most promising project to cope with energy conservation launched recently by the government is the Demand-side Management (DSM). This project is aimed at increasing the electricity utilization efficiency of power consumers. The project cost is 4,570 million baht equivalent to US$ 183 million for 5 years aimed at saving of 225MW of peak demand. The project will require technology transfer on high efficiency light bulbs, high-efficiency electrical appliances, cogeneration equipment, etc.

3. Industrial cogeneration

This section will discuss technology transfer of industrial cogeneration technology to Thailand and assess barriers and opportunities of the transfer process.

Cogeneration known as a simultaneous production of heat and power is an effective means for increasing energy efficiency and reducing energy cost. Cogeneration has been used by U.S. industry since the turn of century. It is widely practised in Europe and elsewhere at present.

In Thailand, the first cogeneration system was installed at Teijin Polyester (Thailand) Ltd. Company in 1974, one year after the first oil crisis. Teijin installed a 9-MW turbogenerator to generate steam and electric power in a cogeneration system.

After the Second Oil Crisis in 1979, the industry has become more concerned about reducing energy costs. Cogeneration has been increasingly applied in other industries such as pulp and paper, petrochemical, cement, etc.

3.1 Technology acquisition

Thailand's economy has grown steadily at a high rate of about 10% during the last 4-5 years, and continues to grow at a slightly decreased rate of 7-8% for the next few years. This is due largely to the continued economic policy of every government to support and encourage investment in the country from both foreign and local investors, with attractive tax privilege from the Board of Investment and without too much control. The private sector grows and builds up their own capability in choices and transfer of technology. A study of Thailand Development Research Institute (TDRI) on Development of Thailand's Technological Capability in Industry in 1989 reveals that large firms have developed their own acquisitive capability to the point that they can be on their own without having assistance from government bodies.

As regards the cogeneration technology transfer, large private enterprises have capable technical and planning staff and access to information and development of cogeneration facilities in industrialized countries. They are capable of making their own study and decision to what technology they will acquire. It can be said that there is no barrier for cogeneration technology acquisition for large firms. For small and medium enterprises, the opportunities for technology acquisition may be limited due to limitation of qualified staff. However, they can be assisted by government agencies concerned or attain a consultancy service from concerned institutions.

In Thailand, a number of distributors or representatives of foreign cogeneration facility companies from the United State, European countries, Japan and Australia are prepared to offer their services. Local companies in association with foreign suppliers are capable of supplying some parts of facilities or installation services.

In conclusion, it can be said that there is no barrier at all for Thailand to acquire cogeneration technology from foreign sources. Foreign producers of cogeneration facilities are willing to provide information and to transfer technology to Thai companies. There are a lot of opportunities for foreign firms to create business in cogeneration and for local industry to acquire cogeneration technology.

3.2 Technology absorption

Cogeneration is the simultaneous production of heat and power. Cogeneration technologies have been developed up to a stable state that the Thai industry is familiar with. Widely used cogeneration technology in

Thailand today is the steam-turbine cogeneration of topping cycle where steam produced from boiler at high pressure and temperature is fed to run a steam turbogenerator to produce electric power. Steam is either extracted from steam turbine at a medium pressure or exhausted without condenser to be used in the process. The industry has no difficulty in absorbing this kind of cogeneration technology.

The second cogeneration technology that has become more popular in Thailand is the Diesel cogeneration when exhaust gas heat is recovered in a heat recovery boiler producing steam for process steam requirement. This technology also is not difficult to be absorbed by the industry In the technology transfer agreement, training for engineers and technicians is normally provided by the technology suppliers.

The third cogeneration technology is perhaps the gas-turbine cogeneration with waste heat boiler. The basic cycle consists of a gas turbine, heat recovery boiler and a process heating load Gas turbine cycles provide the opportunities to generate a large power output per unit of heat required in the process relative to non-condensing steam turbine cogeneration cycle. In the past due to restriction of power production, industry could not sell their excess power produced to the grid, gas turbine cogeneration was not suitable for Thai industry At present the government has revised the law concerning power production to allow private power producers from cogeneration to sell back excess power to the grid, gas turbine cogeneration is likely to gain interest of the industry As regards the absorption of technology, it is again not a problem for large enterprises. However, training courses offered by academic institutions in association with experts from cogeneration suppliers would help enhance absorption of technologies for medium enterprises

3 3 Technology adaptation and development

A number of engineering technologies, namely, combustion, steam boiler, steam turbine, gas turbine, diesel engine, heat recovery, constitute cogeneration technologies Thailand has good institutional capability in science and technology in these areas However, since its industry is small as compared to industrialized countries, using of those facilities is limited in number and it is not economically feasible for energy facility industry to set root in Thailand. Even today the government provides attractive incentives for foreign investment for export it is unlikely that cogeneration industry would be

established in Thailand. However, part of cogeneration facility technology such as steam boiler technology has been adapted and developed in Thailand. Frankly speaking, the state of adaptation and development in the industry is still in a beginning state. Only low and medium pressure steam boilers could be manufactured in Thailand. Large firms prefer to deal with the supplier as a turn-key project. It is assessed that there is a potential for steam boiler industry in Thailand to be developed further by joint venture of foreign technology suppliers and Thai partners. With investment incentives from the government and capable manpower in engineering as well as low labour costs it should make the investment beneficial. Market could be both domestic and export through foreign partner distribution channel. Process of technology transfer could be done through training and learning process of the company.

3.4 Examples of cogeneration facilities

A few examples of installed cogeneration facilities will be briefly described including their characteristics and how the technology has been acquired.

a) Teijin Polyester Company Limited (Textile Industry)

The company has installed a 9-MW steam-turbine cogeneration facility and is now in operation. As the company is a Japanese joint venture company, they have an access to cogeneration technology from their mother company in Japan. A Japanese company Hitachi, is the technology supplier. The contract for purchase of cogeneration facilities includes the cost of knowhow, dispatch of engineers, installation, training of personnel and commissioning.

b) National Petrochemical Corporation (Petrochemical Industry)

The company has installed 3 units of gas-turbine cogeneration facilities of 24 MW each. It acquired equipment and technology from a German company, AEG, in almost the same way as Teijin Polyester.

c) Punjapol Group of Companies (Pulp and Paper Industry)

A 38-MW cogeneration system has been installed with the supply of technology and equipment from a foreign company, Hitachi.

In conclusion, it is a common practice in Thailand that the terms and conditions of supply of equipment and technology would be incorporated in the contract between suppliers and purchasers. The technology and knowhow cost is normally included in the equipment cost. It is important that contract signed would guarantee the purchasers of smooth transfer of technology. After

commissioning, the purchasers should be able to operate the facility by themselves.

4. Energy-efficient lighting

4.1 Introduction

In 1990, total electricity consumption in Thailand was 38 BkWh, of which 20% or 7.6 BkWh was used for lighting. Commercial sector consumed about 12 BkWh and about 30% or 3.6 BkWh was for lighting. Therefore, approximately 50% of electric power used for lighting is consumed by commercial sector. It is estimated that 20% of commercial sector lighting electricity consumption can be saved by 780 MkWh per year by using demand side management measure, such as replacing ordinary light bulbs with energy-efficient bulbs.

4.2 Demand side management (DSM)

Thailand's five-year project on Demand Side Management has been launched by the government early this year to support the energy conservation policy The project is to be implemented by the three power utilities with the collaboration of other energy-related public organizations, academic institutes as well as private sector organizations 1

Overall budget has been earmarked at 4 75 billion baht, of which about 1.8 b will be spent on DSM of commercial buildings for the period of 5 years. Half of 1 8 b for commercial buildings program is allocated to efficient lighting

For commercial buildings, the plan targets at two markets. large commercial buildings larger than several thousand square meters in size and small commercial buildings primarily shophouses According to the plan large buildings in the program will receive a comprehensive lighting retrofit with electronic ballasts and 32W lamps, specular parabolic reflectors (fixtures) and automatic controls where appropriate. Small buildings are mainly shophouses lit almost entirely by 40W fluorescent tubes The buildings would receive a package consisting of 32W tubes and efficient magnetic ballasts to replace existing equipment A special project to assess the cost of providing energy efficient lighting for all of the temples and religious schools and buildings in Thailand will be established It should be possible to promote the use of efficient lighting which will be both the 32W tubes with efficient magnetic ballasts and compact fluorescent lamps The latter will be used to replace the

low-efficiency incandescent lamps. It is estimated that about 4-5 million 32W lamps with either electronic or low-loss magnetic ballasts will replace the existing 40W lamps in the project for the next 5 years.

4.3 Research and development

A typical 40W tube and ballast together consume about 50W. An alternative is an efficient 32W tube with a low-loss magnetic ballast consumes only 36W emitting light lumen equivalent to that of 40w. With electronic ballast, less than 33W will be consumed. The price of an electronic ballast is much higher than a magnetic ballast which at present is not attractive for users. However, it is envisaged that in the long run, research and development to reach low-cost technology and mass production would bring down production cost and more will be used to replace the existing ones

For this reason, the Department of Energy Affairs is now interested in developing electronic ballast and has sponsored a research project to a researcher at Chulalongkorn University It is hoped that knowledge of technical characteristics and design experience would help in technology transfer to Thailand

4 4 Technology transfer

As a result of DSM program, it is estimated that more than 4 million 32W energy-efficient fluorescent lamps will be used to replace the existing 40W lamps With energy conservation policy and incentives from the Energy Conservation Funds, it is anticipated that these lamps will be widely used by new buildings It is then an appropriate time for Thailand to transfer technologies regarding energy-efficient fluorescent tubes, low-loss magnetic ballasts, electronic ballasts and compact fluorescent lamps

4.4.1 Technology acquisition

The role of the government is to encourage investment for production of energy-efficient equipment by offering incentives through the Board of Investment

The private sector will seek opportunities to either set up new lines of business

Since Thai industry has been developed to a mature state, most of them are able to make up their own minds in selecting technologies. The factors that they may consider essential for technology suppliers are past record of

performance, well-developed technologies, reasonable licensing fees and friendly partnerships.

Barriers and Opportunities: The market of fluorescent tubes in Thailand is sizable. Approximately 35 million fluorescent tubes were sold in 1990. There are 9 manufacturers of fluorescent tubes, of which Phillips co. takes the largest shares of 35% followed by Toshiba 30%. There will be no barrier to acquire energy-efficient lighting technologies from industrialized countries. The acquisition process is normally done by private sector by contacting the technology suppliers, visiting the factories and negotiating. The project feasibility will be made taking into accounts all incentives that will be given by the BOI. If the project turns out to be economically feasible, then agreements can be signed without any control from the government

4.4.2 Technology absorption

Lighting equipment industry has set root in Thailand for almost 20 years. Technologies have been transferred to Thailand through joint ventures and also to local manufacturers New technologies can be absorbed without difficulties. Standard testing laboratories are available to help increase the quality of the products The established linkages between academic institutions and industry have provided means for collaboration in technology transfer by means of training, consultancy and R&D.

4.4.3 Technology adaptation and development

Thailand has developed its science and technology capability for some years through formal education, R&D institutions and learning process in industry. Large industries have developed their own adaptive capability and set up R&D division Technology adaptation and development could be done in the factory, or by collaboration with universities or R&D institutes

5. Conclusion

It is agreeable among different parties that energy conservation measure among others would serve as a means for limiting CO_2 emission. Developing countries unlike industrialized ones have not been successful in energy conservation One barrier is the lack of technologies and knowledge of technology transfer

Thailand is fortunate that it has developed its industry to the state that technology transfer processes have been practiced widely and known to public and private sector. Thailand has enough science and technology capability and manpower for the transfer of technology.

Thailand's policy on energy conservation is clear. It has an energy conservation law as a master measure for implementation. Energy-related organizations have been restructured. Energy conservation projects such as Demand-side Management have been launched.

Industrial cogeneration is now promoted by the government. Recently, there has been a policy change allowing industrial cogenerators to sell their excess power back to the grid at a fair price based on long-run marginal cost. On technology transfer of cogeneration, the Thai industry, particularly large enterprises, are capable of acquiring technology and have enough capability in technology absorption There is a good opportunity to promote cogeneration market in Thailand, since the barrier prohibiting selling back of power to the grid has been removed

Energy-efficient lighting is also being campaigned and promoted through a DSM project High capital costs are seen to be the only barrier to promote the utilization of energy-efficient lighting equipment. However, technologies can be transfered to Thailand by setting up manufacturing plants to produce energy-efficient lighting equipment using investment incentives from the government

STRUCTURING THE EQUITY ISSUE IN CLIMATE CHANGE

We gratefully acknowledge the generous support provided by Dr. Prodipto Ghosh of Tata Energy Research Institute, 9 Jor Bagh, New Delhi, for completing this paper

1. Introduction

The key to an eventual international agreement for regulation of Climate Change is the issue of equity or fairness. Equity is involved in at least the following aspects:

I. Real resource transfers may be involved in the application of regulatory instruments. For example, carbon taxes or (auctioned) tradeable permits may be expected to yield net revenues to the international regulatory authority, and these would need to be shared by countries on the basis of an equity determination. Alternatively, assignments of emissions rights can be shown to also involve actual resource transfers across countries and generations.

II. Actual Climate Change manifestations may impact countries or regions, or generations differentially, and without apparent relationship to their respective contributions to GHGs emissions. The equity dimension relates to assigning punitive or compensatory responsibility for environmental impacts.

The first aspect relates to the sharing of a global common property resource, the atmosphere. The second, relates to compensation for adverse impacts of Climate Change, or alternatively, but less plausibly, resource transfers from regions which may experience favourable impacts. While the first aspect has merited some treatment in the literature, work on the second is still limited.

The issue of equity is also central to any economic analysis of the impacts of different regulatory schemes. Unlike in the case of domestic programs (at least in some countries), no neat separation between efficiency and equity concerns are possible in the case of major global economic issues, because the international community does not have an armoury of policy instruments to redistribute economic output across nations and generations. Accordingly, in the case of Climate Change, any regulatory structure will have to simultaneously determine and embody the equity issue. Since such a detemination will involve resource flows across countries and generations, economic analyses of the regulatory regimes will be contingent on the equity resolution.

The issue is complex, and in this paper we do not attempt anything more than providing an outline of a framework for analysis of the problem.

2. Earlier work

The previous literature on the issue of equity in Climate Change is briefly reviewed as follows:

One doctrine suggests that all human beings should be entitled to an equal share in the global sinks for GHGs emissions (e.g. Aggarwal and Narain (1990), Bertram et. al. (1991), and Grubb (1989)). A stronger version of this principle is furnished by Fuji (1990) to the effect that all persons should have equal quotas of emissions regardless of the country s/he belongs to or the generation in which s/he is born into. In effect, this formulation would require regions which historically have been the principal contributors to increased atmospheric concentrations of GHGs, to compensate regions whose historical GHGs emissions have been lower. Grubb et. al. (1991) furnishes two ethical objections to this principle: First, that the people were unaware in the past of the adverse impacts of GHGs emissions, and their descendants cannot therefore be held responsible for their predecessors use of these resources. Second, that the development process, aided by emissions of GHGs has furnished important positive externalities to all countries, and, by implication, compensation if any is due, has already been secured. Both these objections are dealt with in the analytical framework presented below.

Another line of reasoning, furnished by Young (1991), is that not only ar past GHGs emitters not liable for their appropriation of these resources, but, additionally, their historical emissions levels constitute entitlements on the common-law doctrine of "adverse possession". Grubb et. al. (1991) points out that this doctrine is intuitively unappealing, and in any case pollution rights have no common-law sanction It is indeed, doubtful if the adverse possession principle is sustainable under any modern juridical system in respect of common property.

A less extreme variant of this principle is that of "comparable burdens", which may, or may not, be linked with current levels of emissions. This approach is in line with traditional public finance theory, which views the resource costs of provision of public goods (in this case, global environmental quality or climate), as a societal "burden" which is to be shared by members of

society. Two approaches to equity in this literature are that the (tax) burden should be in line with "benefits received" (differentially) by persons, and that it should be related to "ability to pay". The first approach has the advantage of linking the tax and expenditure sides of the budget, which the second approach does not. However, redistributive concerns cannot be operated under the first principle, and in any case the benefit rule cannot be implemented in most cases because it is difficult to assign benefits of public goods. The second approach has generated several criteria of ability to pay for example, "equal absolute", "equal proportional", and "equal marginal" sacrifice. At this point circularity creeps into the argument, since choosing among these criteria involves the prior acceptance of an equity principle.

A completely different line of argument is furnished by the "natural debt" doctrine (Smith, 1990). This approach argues that all countries have accumulated debts "to nature" in line with their use of environmental resources, including GHGs emissions. Since further increase in GHGs levels may lead to unprecedented risk of Climate Change, it would be advisable to reduce further GHGs emissions, or "liquidate" part of the debt to nature, for which each country may assume responsibility in proportion to their accumulated emissions. This may be done both by reducing GHGs intensity of the economy, as well as by creating offsets, for example through reforestation. Since the economic costs of such measures may vary across countries, and in particular, developing countries may have significant cost advantages in such measures, industrialized countries may transfer resources to developing countries to enable them to adopt such measures, liquidating their own natural debt in the process. Clearly, this formulation does not acknowledge responsibility to others for one's actions degrading the global environment. In other words, the equity content of this approach does not relate to fairness across human beings, and is for this reason, intuitively unappealing. As a practical matter, it justifies only very limited resource transfers across countries.

The developing country perspective may be best reflected in the Fuji doctrine, cited above, which allows for per-capita sharing of global environmental resources, including across countries and generations (i.e., compensation for historical emissions levels). We now proceed to a formal,

analytical derivation of the Fuji doctrine, starting from primitive propositions, and also employing widely reviewed political economy principles:

3. A structuring of the equity issue

"Equity" or fairness is a fundamental, intuitive notion, but deeply intertwined with the idea of "equality." The term 'equality' is used in different senses. It may refer to "equality before the law", i.e., equality of treatment by authorities. Alternatively, it may refer to "equality of opportunity", i.e., equality of chances in an economic system. A third meaning is "equality of result", i.e., equal distribution of goods. Coleman (1987) seeks to distinguish between these different meanings in the following manner:

Suppose that a system consists of:

(a) a set of positions which have two properties:
  (i) when occupied by persons, they generate activities producing valued goods and services;
  (ii) the persons in these positions are rewarded for these activities, both materially and symbolically;

(b) a set of adults who occupy positions,

(c) children of these adults,

(d) a set of normative or legal constraints on certain actions.

Equality under law concerns (b), (c), and (d). i.e , the normative or legal constraints on actions depend only on the nature of the action, and not on the identity of the actor. That is, the law treats persons in similar positions similarly. Equality of opportunity concerns (a), (b), and (c), i.e., that the processs through which persons come to occupy positions give an equal chance to all. Ordinarily this means that a child's opportunities to occupy one of the positions (a) does not depend on which particular adults from set (b) are her parents. Finally, equality of result has to do with (a ii), i.e , the rewards given to the position occupied by each person are the same, independent of the activity

These three concepts can also be seen as involving different relations of the "State" to inequalities that exist, or arise in society. Equality before the law means that laws do not recognize distinctions between persons that are irrelevant to the activities of the positions they occupy, but that otherwise policies do not attempt to eliminate inequalities as they arise. Equality of

opportunity means that the State intervenes to ensure that inequalities do not cross generations. Equality of result implies that the State periodically or continuously intervenes to ensure that inequalities arising from activities are not accumulated.

In applying these concepts to Climate Change, the first key question is that of the "identification of agents". Ordinary notions of equity involve fairness among human individuals as agents, although often couched in terms of equity between different groups, or classes. An intuitively appealing notion of "agent" in the Climate Change context would be human beings, irrespective of where or when they happen to live. Alternative notions of 'agent', for example, countries, regions, or defined communities are unappealing, if for no other reason than that they are susceptible to fundamental change in character and composition in the time frame of Climate Change. In that case, i.e., with agents as individuals as defined above, sovereign States may assume the role of trustees with respect to their citizens in the matter of equity in Climate Change, and an attribute of sovereignty would be that such a claim of trusteeship is not open to challenge.

In the context of multilateral regulation of Climate Change, given that this definition of 'agents' is accepted, how may we identify the other elements of the system described above? 'Legal constraints on actions' may be interpreted as limitations on GHGs emissions Further, the 'set of positions' would include various occupations resulting in GHGs emissions and resulting in economic reward, no matter where or when located. Finally, 'children', would, at any given generation, mean the members of the succeeding generations.

What would 'equality under the law' imply, given these definitions? Since under this principle, no note must be taken of distinctions which are irrelevant to the activities of the agents, a multilateral regulatory framework cannot distinguish between individuals on the basis of nationality, temporal generation, or other attributes, such as race, religion, or colour. WE thus establish one component of the Fuji doctrine, that emissions rights across human beings cannot be differentiated spatially or temporally. Equality under law is generally considered the weakest equity principle, to which even an minimalist State may be expected to adhere. It would be difficult to argue against following this principle, in the multilateral Climate Change context.

What of 'equality of opportunity'? This principle requires that inequalities (in wealth, welfare) arising from differential levels of GHGs emissions do not carry over across generations. Specifically, at a minimum this principle would seem to require that the access to GHGs emissions cannot be hereditary, (ruling out "Grandfathering" as a basis for emissions entitlements), and that the incremental wealth accruing to individuals from higher, unentitled GHGs emissions by them, cannot be bequeathed to their offspring. This principle furnishes the basis for the assertion that societies with higher historical per-capita emissions, should compensate societies with lower past per-capita emissions, a second attribute of the Fuji doctrine. Additionally, it counters Grubb's argument, cited above, that compensation for historical emissions is inappropriate because the earlier generations were innocent in their emissions behavior. The Fuji doctrine, in this derivation, is not punitive. Ensuring equality of opportunity is a central concern of the welfare State, and (to varying degrees) is sought to be realized in all but avowed legally minimalist States. Little support may be found in international public documents, or current instruments, for abrogating this principle.

Finally, 'equality of result'. Different ethical schools have evolved to address this question, albeit in the context of distribution of the national income between different social classes or groups.In the Climate Change context, this principle should be interpreted as equal per-capita rights to GHGs emissions across all agents.

Several philosophical positions take equality of result as 'natural', in the sense that while it needs no justification, deviations from the principle would require it. Rawls (1971), accordingly seeks to address the question: "When can inequalities of result be justified?" The answer, summarized in a sentence, is that "only those inequalities are just, which would make the least well off person in society better off than that person would be, (given ceterus-paribus and that that basic human rights are equally assigned to all), in the absence of the inequalities." Rawls' theory of justice would thus cast a strong onus on advocates of differential per-capita GHGs emissions entitlements to demonstrate that any scheme of unequal entitlements would be of greater benefit to the poorest of mankind, than equal entitlements.

Traditional welfare economics based on Utilitarianism, would support the idea of equality of result in income, since declining marginal utility of income would mean that social welfare, an aggregation of individual utilities (cardinal, inter-personally comparable), is maximized when incomes are equal (Pigou, 1932) A progressive per-capita distribution of GHGs emission rights (i.e., emissions rights for the poor are higher than for the rich) might have the effect of equalizing incomes, and thereby, increasing global social welfare. Of course, the underlying assumptions for existence of such a social welfare function are strong. However, there is another objection to the Pigouvian result. That is, if individual welfare is inter-dependent, or in other words, if one person's activities benefit or harm others, even if such external effects are unintended, maximization of social welfare over time would require such external effects to be taken into account. This would mean an allocation of resources to persons in line with the value of these external effects, justifying some inequalities. This argument, as noted above, has also been furnished by Grubb. Of course, the application of this principle must be comprehensive, i.e., all external contributions of all persons over all time must be accounted for. This would allow, for example, for developing countries which were the cradle of human civilization, to claim resource transfers to them for their fundamental contributions to the human state It is difficult to see that practical ways of implementing this principle can be devised.

Libertarianism (Nozick, 1973) points out that a preferred (say, equal) societal distribution of resources at one point in time will lead, by the very process by which persons pursue their own welfare, to less preferred (unequal) distributions at later times The three ways to prevent this, i.e., preventing economic exchange, or banning economic activities which lead to inequality, or progressive taxation, can each be shown, in the limit, to reduce societal welfare. In other words, continuous interventions by the State to restore the preferred resource distribution may lead to reduction in societal welfare. The Libertarian premise is thus, that intervntions by public authorities to promote equality of result is unjustified. Nozick further asserts that distribution of resources cannot be seen in isolation from the process by which wealth is created. "Whomever makes something, having bought or contracted for all other held resources used in the process (transferring some of his holdings for these cooperating factors), is entitled to it. The situation is not one of somethings

getting made, and there being an open question of who is to get it. Things come into the world already attached to people having entitlements over them."

This "historical entitlement theory" would seem, as applied to goods which come into being with pre-existing claims to them, arising for example, from initial property rights over the factors of production, or from the application of one's skill, to deny that equal rights to these goods is natural. However, this would not be the case with resources which are virginal in nature, and Nozick has difficulty in specifying which of several possible methods, for example, through labour, first occupancy, possession, declaration, or some other historical means is appropriate. Steiner (1977) has pointed out that since the process of acquisition of natural resources (which would clearly include environmental resources) creates nothing new, but involves the extraction of pre-existent resources from nature, differential entitlements to virginal resources should be proscribed by the Libertarian Moreover, the equal right to liberty to which Nozick (apparently) subscribes should imply an initial equal distribution of natural resources. It is thus possible, even from the premises of Libertarianism, to derive the principle of equal per-capita rights to GHGs emissions.

Developing countries assert that their levels of past, current, and (foreseeable) future per-capita GHGs emissions would not aggregatively induce Climate Change. On the other hand, just the past rates of emissions of industrialized States suffice to ensure increasing concentrations of GHGs in the atmosphere Further, because of the apparent close linkages betwen economic growth and GHGs emissions, developing countries cannot accept any committment with regard to their emissions levels in the foreseeable future. In addition, equity principles, as argued above, would justify compensatory transfers to them for the historically high levels of emissions by industrialized countries

The final component of the Fuji doctrine, i.e., equality of per- capita emissions rights, accordingly derives from the principles of each of three major ethical schools.

4. Concluding comment

The arguments of the developing countries, formally embodied in the Fuji doctrine, and derived formally in th present paper, cannot easily be dismissed, even if one urges that in their own self- interest, because of likely adverse environmental impacts, developing countries should eschew GHGs intensive growth paths. However, a determination of the equity issues in Climate Change before the current multilateral efforts to finalize a Framework Convention for regulating Climate Change are concluded, is unlikely. Two possible operative aspects of such a Framework Convention are committments by industrialized countries to stabilize and then reduce GHGs emissions, within a specified time-frame, and second, financial flows to developing countries to adopt strategies to reduce future growth of GHGs emissions by them. The first aspect is unexceptionable from the point of view of developing countries, as long as similar committments are not sought from developing countries before a determination of equity principles. Regarding the second, two considerations are important. One, that such flows must be additional to, and not competitive with, normal aid flows for growth. Second, that financial (and technology) flows, without an equity determination (when then might accrue as of right), must be considered as paternalistic, and no obligation can be cast on anyone to accept such transfers. Accordingly, it would be inappropriate to prescribe binding norms for such financial or technology transfers, and it should be open to individual countries to state the conditions under which they would accept such transfers.

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